THURSDAY, OCTOBER 11, 1888.

## *THE ZOOLOGICAL RESULTS OF THE "CHALLENGER" EXPEDITION.*

*Report on the Scientific Results of the Voyage of H.M.S. "Challenger" during the Years* 1873–76, *under the command of Captain George S. Nares, R.N., F.R.S., and the late Captain Frank T. Thomson, R.N.* Prepared under the superintendence of the late Sir C. Wyville Thomson, Knt., F.R.S., and now of John Murray, one of the Naturalists of the Expedition. Zoology—Vol. XXVI. Published by Order of Her Majesty's Government. (Printed for Her Majesty's Stationery Office, and sold by Eyre and Spottiswoode, 1888.)

THE first memoir in Vol. XXVI. is the second part of the Report on the Crinoidea collected during the voyage, and is by Dr. P. Herbert Carpenter. The first part treated of the Stalked Crinoids: this treats of the Comatulidæ.

Since Müller's well-known memoir on the genera and species of the Comatulidæ, no systematic work on this interesting group has until now made its appearance. Several new species have no doubt during these forty years been described, but with the publication of each the subject became more and more confused, and the painstaking and laborious revision of the known species forms by no means the least important portion of the present memoir. In it we find the result of many years' careful study of the "Comatulæ," based not only on the collections made by the *Challenger*, but on those made by other Expeditions in various seas, and on the examination of almost all the types to be found in European or American Museums.

Lamarck's familiar and appropriate name Comatula is retained by the author as the name of a family of Neocrinoids, which now contains six genera with recent species, viz. Antedon, Actinometra, Atelecrinus, Eudiocrinus, Promachocrinus, and Thaumatocrinus: of these genera over 180 species are now known, a large advance beyond the 35 species referred to by Müller, and of the former number 88 are described in detail as new from the *Challenger* collections. The author remarks that even this large number is considerably lower than that mentioned in his preliminary Report, but adds that the large experience gained by the examination of numerous specimens has obliged him often to write under one specific name forms which at first had seemed most distinct.

This Report is morphological, as naturally the opportunity was wanting for dealing with details of development. We have first a general introduction, in which there is a sketch of the progress made from the days of de Fréminville; next a chapter on the centro-dorsal plate and calyx, in which there is no lack of controversial matter. The errors of Vogt and Yung might better have been referred to in footnotes, and the continuance of the author's descriptions would not then have been interrupted. It scarcely concerns the reader who is studying Carpenter to know what "the student of Vogt and Yung" would or would not learn from their writings.

The chapter on the geographical and bathymetrical distributions is an important one. Our present knowledge of the recent species is too imperfect for any generalization respecting their geographical distribution or the origin of specific types. The species occur in immense abundance over certain large areas, such as the Caribbean Sea, and more especially the Eastern Archipelago and Australasia. The species of other seas have been made known to us by the dredgings of the *Challenger;* and other collections, both from the Arctic and sub-Arctic seas and from the Southern Indian Ocean, have yielded some valuable information. Although abundant near the coasts in the Arctic Ocean and on both sides of the North Atlantic, no species has been dredged at a greater depth than 800 fathoms in the Atlantic, nor were any forms met with in either of the *Challenger's* two traverses of the North Atlantic; and, while one species is recorded from Madeira and the Canaries, none have as yet been found at the Azores, Cape Verdes, or Bermudas. The two Mediterranean species range as far north as Scotland. In the Florida Channel, and in the Caribbean Sea, Comatulæ abound. None are known from the African coast, between Cape Verde and the Cape of Good Hope, except one species met with at the equatorial island Rolas. The only Actinometra common to both sides of the Atlantic is found at St. Paul's Rocks. Some few of the Caribbean species extend therefrom down the South American coasts to Cape Frio; while, in mid-Atlantic, species have been dredged at moderate depths off Ascension, St. Helena, and Tristan d'Acunha. Closely allied to the North Atlantic species are those found at Heard Island and Kerguelen. Various species are found at Simon's Bay, Natal, Madagascar, Mauritius, Seychelles, Zanzibar, Red Sea, Kurrachee, Ceylon, Bay of Bengal; while in the seas of the great Eastern Archipelago they occur in most bewildering confusion. No species as yet have been taken on the coasts of New Zealand—though one or two approach the East Cape of the North Island—nor at Tasmania. Two species are recorded from the Straits of Magellan, and single species are known to occur at Chili and Peru; but there are none apparently on the western shores of North America. In the Pacific the species are extremely rare. While essentially littoral forms, three species were found at depths of from 345 to 755 fathoms, from the green mud off the Japanese coasts; and one, *Antedon abyssicola*, from a depth of 2900 fathoms, at Station 244 in the North Pacific.

So far as present knowledge goes, the Comatulidæ first appeared in the time of the Middle Lias, and were thus of later date than the Pentacrinidæ; they were fairly abundant in the Jurassic and Cretaceous epochs, especially so at certain periods. The recent forms occupy an immensely more extended area than the extinct ones, for, with the exception of a species of Antedon from Algiers, and another from Syria, no fossil Comatulid has been found out of Europe, not even in the Indian Tertiaries, otherwise so rich in Echinoderm remains; and while none are to be found in America, it is not without interest to note that Pentacrinoid remains are very common at certain horizons of the Jura Trias over wide areas of the western territories, thereby indicating that the conditions of that age were not altogether unfavourable to the existence of Crinoid life. The Middle Lias

of France contains two species of Antedon, the oldest yet known, and the genus occurs together with Actinometra, in the Lower Oolites of both France and England; while if *Bourgueticrinus ooliticus*, McCoy, is a Thiollicricrinus, as supposed by de Loriol, then it is the earliest known species of this remarkable genus.

The fifth chapter is on the classification of the family, and is followed by the descriptions of the specimens. In a seventh chapter there is a detailed account of the bathymetrical distribution, and a station list of all the "Comatulæ" which were obtained by the various British Expeditions for deep-sea exploration between the years 1868–82. Appended to this is a list of all the known living species of Comatulæ, with their distribution in depth and space. As to the latter, all the principal stations are given. In the analysis of this list (p. 383) the total number of living species is given at 180, but from the list itself there would seem to be 188 species. Possibly the seven additional species of Antedon and the one species of Actinometra named but not described may account for this discrepancy. The Report is accompanied by seventy plates.

In congratulating the author on the successful accomplishment of his onerous task, we allude to his apology for the delay in its publication to state our conviction that none such was needed. Investigations like those here recorded might be more quickly accomplished were it possible to devote to them the whole working hours of the investigator's life; but when instead they have to be carried on during the hours of rest from arduous professional duties, hours that might more prudently have been devoted to repose, the case becomes quite different, and the wonder to us is that so much has been done within the time.

The second memoir in the volume is a Report by Sir Wm. Turner on the Seals collected during the voyage. In the first volume of these Reports, Sir W. Turner's Report on the Bones of the Cetacea which had been collected by the Expedition appeared. In the present Report we have detailed descriptions of the species of Macrorhinus, Leptonychotes, Otaria, and Arctocephalus, procured at the Kerguelen and Heard Islands, off the Falklands, in Messier Channel, and at Juan Fernandez. This is followed by an outline of the classification of the Pinnipedia, in which the diagnoses of all the genera and those of most of the known species are given.

In a third part there is a description of the brain of the elephant seal and of the walrus, with a comparison of the convolutions of the brain of the seals and walrus with those of the brains of the Carnivora, and of apes and of man. Part IV. gives an account of the visceral anatomy of the elephant seal. In an appendix there is an elaborate account by Dr. W. C. Strettell Miller of the myology of the Pinnipedia. Ten plates accompany this Report.

The third and last memoir in this volume is an exceedingly interesting supplement to his Report on the Actiniaria, by Prof. Richard Hertwig.

This supplement contains a description of additional specimens found from time to time as the various other groups of marine forms were being worked out. Amongst the material occurred species previously described, but enabling in a few cases fresh details to be added. Several, however, represented new and interesting genera, but in some cases the material was in so bad a state of preservation as to preclude description. Prof. R. Hertwig's Report was published in 1882, and since then Andres's monograph of the Actiniaria has appeared. Some criticisms on his classification preface the description of the new species; and a synopsis of the Hexactiniæ according to Hertwig's views, is given.

In the description of genera and species we find an account of a new species of Moseley's genus Corallimorphus, *C. obtectus*. It was found at Station 157, and on it Hertwig in his Report had chiefly based his description of *C. rigidus*, Mos., the type specimen of which latter has now been found. A new genus, Ilyanthopsis, is established for a single specimen from the Bermudas; it seems in shape intermediate between Aiptasia and Anemonia; it was attached. Aulorchis is a new genus belonging to the group of forms devoid of tentacles, the specimen (*A. paradoxa*) was found at Station 299, at a depth of 2160 fathoms. With the assistance of Dr. Erdmann, a revision of the Zoantheæ is given, based on an examination of the condition of the cœnenchyma, arrangement of mesenteries, structure of sphincter, condition of integument, and colonial formation. The solitary forms are relegated to Sphenopidæ, the colonial to Zoanthidæ, of which five genera—Zoanthus (Cuv., p.p.), Mammilifera (Lesueur), Epizoanthus (Verrill), Polythoa (Lamx.), and Corticifera (Lesueur)—are recognized. In an appendix a new genus and species is described, *Stephanidium schulzii*, found off Zebu, which appears to belong to the Zoantheæ, but differs in the absence of incrustations and the non-formation of a colony.

We notice one defect in this memoir, that the references to the authorities for known genera and species are omitted. There are four plates representing the new forms.

## OUR BOOK SHELF.

*A Bibliography of the Foraminifera, Recent and Fossil, from* 1565 *to* 1888. By C. Davies Sherborn, F.G.S. Pp. i.–viii. and 1–152. (London: Dulau and Co., 1888.)

THE attention of naturalists for many years has been drawn to the minute animals of the sea, and with increasing interest as they have become better known by researches as well in abyssal as in shallow waters. Their fossil representatives have also long been noticed and extensively sought for in very many strata of different ages in various parts of the world.

The Foraminifera are among these multitudinous objects of interest to the microscopist, and through him to the naturalist in general, and the geologist in particular.

The simplicity of structure in the Foraminifera, and, at the same time, their manifold and indeed interminable varieties of form, often symmetrically elegant, have given rise to numerous namings and descriptions, often without adequate figures. Hence their nomenclature has been confused among the multitude of authors who have either mentioned, or more fully treated of, these minute organisms. Consequently, for a basis in determining the relative value of the so-called species, their right names, and order of discovery, a bibliography of the Foraminifera, having long been desiderated, was attempted by different writers in 1848, 1854, 1858, 1859, 1878, 1884, and 1886–8; but each of these catalogues was imperfect. We are pleased to be able to say that a complete list of the books and papers treating of Foraminifera is now before us, combin-

ing accuracy and fullness of detail as to title, author, date, size, and place of publication. A short note of explanation or pertinent remark is in many cases added to the entries of the rare and little-known publications. Mr. Sherborn thus enumerates about 700 authors, with full title of book or memoir, carefully systematic abbreviation of titles of periodicals, and place of publication as given in the originals. Notices and general reviews having original information are included. Mr. Sherborn has examined all the works he has catalogued, with very few exceptions, and these are properly marked "not seen." The authors most prolific of memoirs are Brady, Carpenter, Carter, Dawson, De la Harpe, D'Orbigny, Ehrenberg, Folin, Fornasini, Gümbel, Haeusler, Hantken, Karrer, Jones, Munier-Chalmas, Neugeboren, Parker, Reuss, Robertson, Schlumberger, Schultze, Seguenza, Soldani, Stache, Terquem, Terrigi, Uhlig, Van den Broeck, Wallich, and Williamson. Former lists have evidently been carefully collated and corrected: and the life-dates (birth and death) of deceased authors have been entered as far as possible.

Several of the older papers are now catalogued for the first time, such as "Camerarius's papers, 1712 and 1717; Klein's, 1754; Schroeter's, 1803; and Wulfen's, 1791"; we also find "the correction of the hitherto inaccurate references to Spengler's papers; the original place of publication of Modeer's letter to Soldani; and Ricca's 'Discorso,' with the engraved portrait of Soldani"; and, "among those of scientific importance, ... the earlier issue of Fichtel and Moll (which carries back their scientific names five years); D'Orbigny's list of the Foraminifera of the Vienna Basin, published by J. von Hauer seven years before the full description appeared; the note on D'Orbigny's 'Planches inédites'; Boué's paper on the Nummulites; and Silvestri's rare and interesting paper on Soldani's 'Testaceographia.' For the first time, too, an endeavour has been made to enumerate the important memoirs published by the Hungarian authors with some approach to completeness."

The whole work has been conscientiously done, with scrupulous exactness; and the industrious author has made it a labour of love for several years, since he began to study Foraminifera. Having so full a knowledge of the subject, he might with advantage, we venture to think, give further aid to students and others by publishing an index and synonymy of all the recorded genera and species of Foraminifera.

In the preface to the bibliography, Mr. Sherborn fully acknowledges the help he has received from his many friends at home and abroad; and he refers to such analogous and collateral bibliographies as have been aids in his research. This work will without doubt be fully appreciated by biologist and palæontologist; and we cordially agree with the author in his remark that "sincere thanks are due to Mr. F. Justen (Dulau and Co.), to whose generosity and scientific sympathies I owe the publication of my manuscript." T. R. J.

*Earth Knowledge.* Part II. By W. J. Harrison, F.G.S., and H. R. Wakefield. (London: Blackie and Son, 1888.)

THIS book, in conjunction with the companion volume issued a few months ago, is chiefly intended for the use of students preparing for the Science and Art Department's examinations in Physiography. The book is far too small for its subject, and in consequence, only very bare outlines of the different branches of the subject can be given, and much is omitted which we should expect to find. It is scarcely possible, for instance, to give an adequate amount of information about the sun in half a dozen small pages; yet the authors have attempted to do this, and the result is what might be expected—namely, a very scanty chapter. No mention is made of the fact that the corona is of variable form, and since only one drawing is given, a student would be likely to infer that its form is constant. Again, the possibility of observing prominences whenever the sun is visible, and the peculiarities and variability of sun-spot spectra are not touched upon at all. No chapter on the sun can be regarded as complete which does not treat of the various solar phenomena in relation to the sun-spot period.

Again, the classification of stars according to their spectra (p. 78) is not treated nearly so fully as its importance demands. Notwithstanding the fact that there are two distinct kinds of red stars, one giving indications of metallic fluting absorption, and the other of carbon absorption, we are simply told that in the red stars the lines are more numerous than in stars like Arcturus (p. 79).

On p. 126 we read:—"Although the sun's mass is so very much greater than that of the moon—being nearly sixty million times as great—yet the tide-producing force of the sun is only about seven-sixteenths that of the moon, because the sun is nearly 400 times farther off the earth than the moon." Although this statement is quite true, a little further explanation is necessary to make it consistent with the arithmetical fact that sixty millions is greater than the square of 400. It is only fair to say, however, that the importance of considering the differential attractions of the sun and moon on opposite sides of the earth, instead of the total attractions, is well brought out with regard to the precession of the equinoxes.

On the whole, the drawings are excellent, but that on p. 29, showing the action of the spectroscope, is rather misleading; we would remind the authors that the slit is usually placed in the principal focus of the collimating lens, and that there is nothing to converge the rays of light to a point inside the tube.

Without the aid of a well-informed teacher, the book is far from sufficient to fulfil the purpose for which it has been written.

*An Introduction to the Science and Practice of Photography.* By Chapman Jones, F.I.C., F.C.S. (London: Iliffe and Son, 1888.)

WE have here quite a new departure from the ordinary books on photography, the subject being treated not from the mechanical but from the scientific point of view, and the author has succeeded in placing before us a very useful work.

The volume is divided into three parts. The first consists of fifteen chapters, the more important among them treating of the transmission and intensity of light, reflection by plane and concave mirrors, refraction of light and the forms and properties of lenses, &c., concluding with a chapter on the spectroscope, colour-sensitiveness, and the absorption of light. In Part II. are described various forms of cameras, camera-stands, exposure-shutters, followed by some very interesting chapters on the history and special properties of the many and various forms of lenses. Part III. consists of twenty-four chapters extending over 100 pages, in which are described the manufacture of collodion and gelatino-bromide plates, and all the different modes of developing, printing, toning &c., including carbon-printing, Woodburytype, and other photo-mechanical processes.

In the appendix are tables of English weights and measures, and a comparison of them with the metrical system, preceded by an explanation of the methods of testing lenses. The volume is well illustrated, and the varied information contained in it ought to give it a wide circulation.

*Numerical Examples in Practical Mechanics and Machine Design.* By Robert G. Blaine, M.E. (London: Cassell and Co., Limited, 1888).

IN this volume there is an excellent collection of examples, the teaching power of which has already been

tried by students attending the lectures at the Finsbury Technical College, who, as is stated in the preface, written by Prof. John Perry, have worked through them and obtained "a real good working knowledge of the application of the principles of mechanics and machine design; . . . their knowledge was always ready for use."

The examples, as a rule, are thoroughly practical, and may be taken as illustrating Prof. J. Perry's book on "Practical Mechanics," and Prof. Unwin's book on "Machine Design."

To make the volume more complete, useful rules and constants, together with tables of sines, cosines, tangents, and cotangents, of angles from 1° to 45°, are added, concluding with a table of the squares, cubes, square roots, cube roots, and reciprocals of all numbers from 1 to 100, and of approximate fifth roots from 1 to 1000.

*A Text-book of Physiology.* By M. Foster, F.R.S. Fifth Edition. Part I. comprising Book I. (London: Macmillan and Co., 1888.)

THIS work was originally published in 1876, and it has become so widely known that we need not now do much more than note the appearance of the first instalment of a new edition. In this edition—the fifth—considerable changes and additions have been made. The changes, however, do not affect the character of the book; and Prof. Foster explains that the additions, with the exception of the histological paragraphs, are caused, not by any attempt to add new matter or to enlarge the general scope of the work, but by an effort to explain more fully and at greater length what seem to him to be the most fundamental and most important topics. He has introduced some histological statements, not with the view of in any way relieving the student from the necessity of studying distinct histological treatises, but in order to bring him to the physiological problem with the histological data fresh in his mind. Hence in dealing with the several histological points the author has confined himself to matters having a physiological bearing. This first part will be followed as soon as possible by the second and third parts.

*The Analyst's Laboratory Companion.* By Alfred E. Johnson. (London: J. and A. Churchill, 1888.)

DURING the past four years, Mr. Johnson has had in everyday use in the laboratory a manuscript book of factors and tables. The work grew by constant additions, made as required; and in the end, as he explains in the preface, it became complete enough to encourage him in the belief that it might prove useful to analysts generally. Accordingly he has issued the present little volume, and no doubt he is right in thinking that the large amount of labour involved in the calculation of the many original tables here published may be found to save much of the time otherwise required by the analyst in working out the results of analysis. For the convenience of students not well acquainted with logarithms, of which he has made free use, he has given an account of them, adding examples fully worked out and chosen so as to include and explain the difficulties generally felt in connection with this subject.

## LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

### Prophetic Germs.

I REGRET to find that I put an erroneous interpretation upon the phrase "non-significant organs," as used by Prof. Ray Lankester. I never doubted that it meant organs or structures which were non-significant in respect to actual use; that, in short, it was his phrase for what other men have variously called aborted or rudimentary organs. He now explains that "non-significant," in his terminology, means any variation from hereditary forms which is fortuitous—as unknown in respect to its origin as it is in respect to its actual or future use. Although I see no value in this phrase as descriptive of anything that exists, I see great value in Prof. Ray Lankester's admission that natural selection cannot act upon any structure which is not already developed up to the stage of actual use. This is really all I want for my previous argument, because all organs whatever do actually pass through rudimentary stages in which actual use is impossible. In no possible case, therefore, can selection explain the origin of any organic structure. I rejoice to find Prof. Ray Lankester denouncing as "an absurdity" the idea that "congenital variations are selected when they are not of any actual use." It must therefore be quite according to the admitted constitution and course of Nature that we should find organs "on the rise," as well as organs "on the wane." All germs must be prophetic of their future use, so long as they are in germinal stages; and, if evolution be true, the world ought always to have been full of them, and ought to be full of them now, unless the creative or evolutionary work has been arrested, at least locally, and for a time.

ARGYLL.

Inveraray, Argyllshire, October 8.

### The Geometric Interpretation of Monge's Differential Equation to all Conics.

WITH reference to the remarks of "R. B. H." (NATURE, June 28, p. 197) on my interpretation of the differential equation to all conics, I wish to point out that the objections he seems to take do not appear to be well founded. The difficulty he finds is that the geometrical interpretation given amounts to the fact that "a conic is a conic." But it is easy to see that there is no peculiarity in this; it arises simply from the well-known fact that all the geometrical properties of any given figure are inter-dependent: one of them being given, the others may be deduced as legitimate consequences from it. "R. B. H." takes the proposition which constitutes my interpretation, and then, coupling it with the other theorem that the osculating conic of any conic is the given conic, comes to the conclusion that a conic is a conic, and, apparently, he takes it to be very strange; but, as a matter of fact, given *any two* properties of a conic (or of any other curve), we can only come to the conclusion that the conic is a conic (or that the given curve is what it professes to be). Take, for example, the geometric interpretation of the differential equation of all right lines, which is $q = 0$; it simply means that the curvature vanishes at every point of every right line, which is equivalent to the fact that a straight line is not curved, or that a straight line is a straight line. There is certainly nothing strange in this: it is the legitimate effect of the process employed. Would "R. B. H.," on this ground, reject the geometrical interpretation of the differential equation of all straight lines? Surely the process is nothing but a piece of quite unobjectionable verification. Similarly, the differential equation of all circles, $(1 + p^2)r - 3pq^2 = 0$, means that the angle of aberrancy vanishes at every point of every circle. Combining this with the self-evident proposition that the normal and the axis of aberrancy coincide in the case of a circle, we may come to the conclusion that a circle is a circle; but I submit that this is really a verification, and surely no ground for rejecting the interpretation. Indeed, the question whether such processes are to be regarded as verifications or not seems to me to be much the same question whether every syllogism is a *petitio principii* or not. But as I have elsewhere, in the papers referred to in my last letter (p. 173, *ante*), fully discussed what a geometrical interpretation properly ought to be, I need not enlarge further on this point.

As to the difficulty which "R. B. H." feels in drawing a curve at every point of which the radius of curvature vanishes, I may remark that this is a "limiting case," and the matter becomes clear when my interpretation is paraphrased thus: "If the radius of curvature of the aberrancy curve of a given curve vanishes at every point, that curve degenerates into a conic."

Finally, I fail to see why an interpretation is to be rejected simply because the property it enunciates happens to admit of an easy verification. The conic has an infinite number of properties, and the chief difficulty in discovering the geometrical interpretation of its differential equation has been to find out which

of these numerous properties is adequately and most appropriately represented by the Mongian equation. The question has been, what fact in the history of the conic, if I may say so, is most intimately associated with the vanishing of the Mongian; and that fact, I believe, is given in my interpretation. Whether the fact admits of an easy verification or not seems to me to be wholly foreign to the question.

Calcutta, July 27. ASUTOSH MUKHOPADHYAY.

### Upper and Lower Wind Currents over the Torrid Zone.

AFTER my arrival in China in 1883, I made inquiries, among persons who had kept meteorological registers, concerning the direction from which clouds usually come here, but was told that they came from all directions without any apparent order. But the observations made during January 1884, printed in the Weather Report published on February 11, showed at once clearly that the lower clouds came from the east, and that the directions veered with increasing height, the highest clouds coming from the west, as explained in the text of the Annual Weather Report published on February 17, 1885. This might have been expected in analogy with what obtains in cyclones, as the trade-wind blows into the calm belt as if this were the centre of a depression drawn out to extend round the whole earth near the equator.

The Hon. R. Abercromby, to whom my Reports were sent without delay, convinced himself of the truth of those remarks during a tour round the world, and addressed a letter to NATURE on the subject on October 26, 1885, but it is of importance that the subject should be investigated at fixed observatories within the tropics, where hardly enough attention has hitherto been paid to the movements of clouds, to judge from what has hitherto been published.

In the Annual Weather Report for 1885, it is stated that, from June to September inclusive, cirri come from two different directions—from about north-east while a typhoon is in existence somewhere, their direction often backing from about east to north while the centre of the typhoon is yet over 700 miles away; and from about west when there are no signs of a typhoon. But cirri are rarely seen in summer except before typhoons, through whose agency vapour is evidently carried up to the higher regions of the atmosphere. It is, however, to be expected that the existence of the southerly monsoon (caused by the low barometer in the northern part of the Chinese Empire) during the summer to some extent influences the movements of the clouds.

The following table exhibits from four years' observations (1884 to 1887 inclusive) the average directions from which the wind comes at the Observatory, about 150 feet above M.S.L., and at the Peak about 1850 feet above M.S.L., as well as the average directions from which the upper and lower clouds come, but the difference between the latter is so great that intermediate directions will be missed:—

| Month. | Obs. | Peak. | Lower C. | Upper C. |
|---|---|---|---|---|
| January ... | E 11° N ... | E 10° N ... | E by S ... | W by S |
| February... | E 15 N ... | E 17 N ... | E by N ... | W |
| March ... | E 4 N ... | E 17 S .. | ESE ... | W by S |
| April ... | E 3 N ... | E 30 S ... | SE ... | W by S |
| May... ... | E 11 S ... | E 44 S ... | SSE ... | WNW |
| June... ... | E 51 S ... | E 67 S ... | S by E ... | NNW |
| July ... ... | E 46 S ... | E 87 S ... | S by E ... | NE |
| August ... | E 72 S ... | S ... | S ... | NE |
| September | E 12 N ... | E 1 N ... | ESE ... | NNE |
| October ... | E 15 N ... | E 8 N ... | E by N ... | W by S |
| November | E 28 N ... | E 19 N ... | ENE ... | W by S |
| December | E 26 N ... | E 18 N ... | E by N ... | WSW |
| Mean ... | E 6 S ... | E 22 S ... | E 30° S ... | W 33° N |

If an observer outside the earth were to determine the period of this planet's rotation by observing spots formed by clouds, he would obtain different values according to the level of the respective cloud-layer, just as we obtain different values for the period of rotation of Jupiter from observations of different classes of spots. In the case of the earth, the observation of the highest clouds near the equator might possibly furnish a value of the period too short by a tenth, and there is no doubt it would be different nearer the Poles. W. DOBERCK.

Hong Kong Observatory, August 11.

### The Natural History of the Roman Numerals.

SOME time ago I had the pleasure of reading in your journal (vol. xxxvi. p. 555) an interesting article by Mr. Lymburn on the above subject. In this the writer shows the probable evolution of the X ten, from the V hand, and thence the broad arrow, ↑. As the Scandinavians used this arrow sign, calling it *tir* or *tyr*, as an equivalent for T in the Runes (see Taylor, "The Alphabet," vol. ii., p. 18), it is therefore connected with the Greek *tau*, the headless cross, the X of the Semitic languages. I have no doubt that many of your readers take an interest in anything bearing on this subject. This is my apology for calling their attention to an article published in the last volume of Transactions of the New Zealand Institute,[1] wherein I break new ground by showing that the word *tau* was known in Polynesia as a cross, as ten, and probably as meaning "writing."

I have given, in the different dialects of New Zealand, Samoa, Tonga, Hawaii, &c., the meanings of the word, and shown its entry into other compound words. A brief *précis* runs as follows:—

*Tatau* (*ta-tau*) is the Tahitian word which Cook brought to us, and is better rendered by his spelling *tattow* than by our English *tattoo*. In Maori, *tatau* means to count, to repeat one by one; but in Hawaiian it means to write, to make letters upon, to print as upon *tapa* (native cloth) as in former times. In this Hawaiian, *tau* means to dot, to fix the boundaries of a land or country, to give publicity to a thing. In Tahitian, *tatau* means not only to tattoo, but to count, number; in Samoan, *tau* is to count, and in Marquesan, *tatau* to reckon. In composition, too, it enters into many words, such as teacher, pupil, genealogy, &c., and it seems impossible but that the tattooing (at one time done in "three-marks" and arrow-heads) meant some kind of character or script.

As to the numeral "ten," I bring some interesting evidence which I cannot condense.

As to the figure of the cross being used as a sacred sign, there are innumerable evidences to that effect in the Polynesian islands; notably that the Southern Cross is called in Tahitian *tau-ha* ("four-cross"), and that the cross X was the taboo sign in front of Hawaiian temples. I have since learnt that in the Solomon Islands the cross taboos anything to the chief.

Wellington, N.Z., August 5. EDW. TREGEAR.

### Indian Life Statistics.

THOUGH several weeks have now elapsed since Dr. Hyde Clarke's inquiry about the effects of lucky and unlucky times and seasons upon the Indian birth-rate was published (in NATURE of July 26, p. 297), none of your readers in England who happen to be acquainted with India have come forward to answer it. I therefore write to point out that, though the times of Hindu *marriages* are to a very great extent controlled by supposed lucky or unlucky days, months, or years, these have nothing whatever to do with variations in the birth-rate, for the usual age of marriage of girls is from eight to ten years, and child-bearing at the earliest does not commence before twelve or thirteen.

With regard to the *Holi* and other religious festivals, I have it on the authority of Mr. J. C. Nesfield, Inspector of Schools in Oudh, who has made a life-long study of Hindu castes and their customs, that, whatever the origin and primary significance of the *Holi* may have been, it is not now connected in any special manner with the multiplication of the species. The religious ceremony to which the Hindu looks for the furtherance of his desire for offspring is the *Durga Pujah*, or worship of the consort of *Shiva*, which is the occasion of the annual family reunion all over Bengal. In the Upper Provinces a totally different festival is celebrated at the same time of the year—the *Rām Lila*, a sort of dramatic performance or mystery-play, commemorating the expedition of Rāma to Ceylon for the recovery of his lost wife; but Mr. Nesfield says that during the *Rām Lila* some member of every family is specially set apart to conduct a ceremonial worship of *Kāli*, or *Durga*, ending with the sacrifice of a male kid, and that the object of this ceremony is to obtain the favour of *Kāli* and her consort for the continu-

[1] Trans. N.Z. Inst., vol. xx., "Ancient Alphabets in Polynesia," by E. Tregear, F.R.G.S. (London: Trübner and Co.)

ance of the family. Now the *Durga Pujah* and its equivalent ceremony in Upper India occur in October, *i.e.* at the beginning of the healthy season with abundant food-supplies. This is one more instance of the perfect adaptation of the Hindu religious calendar to the natural changes of the seasons.

Allahabad, September 9. S. A. HILL.

### A Shell-Collector's Difficulty.

CAN any of your readers help me in the following case? I am a shell-collector, and my minute and delicate species (*Diplommatina* and such like) are kept in glass tubes. I have lately observed that some of the tubes in the cabinets were becoming opaque; a milky efflorescence seemed clouding the *inside surface*. I found the same thing in a box containing about 100 that I had placed on one side. I then opened a box of 500 which had never been unpacked since they were received, some four years ago. *All* these are more or less affected! I then opened a third box, from another maker, and in this 500 I observed many beginning to be affected. What can be the reason? Each of these tubes is tightly corked, and I see the glass under the cork is *not affected*. I have tried various means to restore the clearness without avail. I have boiled some, and roasted some in the sun, steeped others in alcohol, oil, &c.; nothing seems to do any good. Can any of your scientific readers divine the cause, and suggest a remedy? E. L. LAYARD.

British Consulate, Noumea.

### "Fauna and Flora of the Lesser Antilles."

IN the article on this subject in NATURE of August 16 (p. 371), it is stated that Guilding discovered a *Peripatus* in Dominica many years ago. This is, I believe, an error, for Guilding's *Peripatus juliforme* was found by him in St. Vincent, an island to the south of Dominica, and the first specimen of *Peripatus* found in this island was, I understand, the one now in the British Museum, taken home by Mr. G. Angas.

The rediscovery of the Dominica *Peripatus* is rather curious. In 1883–84, at the special request of Prof. Moseley, I searched for the animal in all likely places, but did not succeed in finding any specimens. At that time Prof. Moseley and I were not aware of Mr. Angas's discovery. I mentioned my non-success to Mr. Ramage, and asked him to look out for the interesting animal, and, strange to say, soon afterwards his boy brought him three specimens, but Mr. Ramage has not been able to obtain any more. I employed the same boy after Mr. Ramage had left Laudat, and he brought me two specimens, and said that he could find no more although he had searched for several days. These two I sent to Prof. Moseley at Oxford. A few weeks ago another specimen was brought to me from the windward (or eastern) side of the island by the same boy, who found it about 300 feet above the sea, not far from the coast. Laudat is on the leeward side, at an elevation of about 2000 feet above the sea, and on the margin of the virgin forest. The six specimens of the Dominica *Peripatus* recently found may not belong to a new species, but the rarity of the animal is interesting. Had it been common in any degree, Mr. Ramage and I must have found it, but neither of us has succeeded in doing so.

Mr. Ramage, who has been labouring with unflagging zeal, leaves to-day for St. Lucia, but he will return here later on in the year, so as to continue his botanical work. His specimens of the forest flora form, I believe, the most complete collection that has yet been made in the island, and his enthusiastic work deserves recognition. H. A. ALFORD NICHOLLS.

Dominica, West Indies, September 15.

### Sun Columns.

WITH reference to the simultaneous appearance of five sun columns described by Mr. Brauner (August 30, p. 414), the following descriptions of three different manifestations of the phenomenon may perhaps be of interest.

April 19, 1887, 7.25 to 7.37 p.m., calm, sky clear except a smoky grayish haze low on the western horizon, behind which the sun had set. The solar rays concentrated into one perpendicular continuous beam of uniform diameter with the sun, and reaching to an altitude of about 20°. The beam sharply defined, and of a reddish tint strong enough to be detected behind the haze. Near the summit a few tinted strips of fine cloud forming an angle, and giving the whole the appearance, as described by the person who called my attention to it, of "a ship's mast and yards." No trace of side rays visible.

June 10, 1888, 8 to 8.25 p.m., sun set below horizon; to an altitude of about 10°, sky comparatively clear, only a little cirro-stratus; above this, to an altitude of 20°, the cirro-stratus much more dense, and in this part only was a sun column distinctly visible, terminating abruptly, and showing no trace in the cirro-cumulus above. In the lower 10° there was also no evidence of the column. It was at first of an old gold colour, then gradually changed to a deeper red by 8.15 p.m., when the clouds on both sides were suffused with the same tint, and by 8.27 it had disappeared.

These two cases I observed from my own residence; the third has been communicated to me by Mr. W. Manning, who was chief officer of the ship *Balmore* when he witnessed the phenomenon. Not having access to the ship's log, he could not give me the exact date and position, but it was some four or five years ago, "in about 25° or 30° S. lat., and from 120° to 130° W. long., during the first dog watch (4 to 6 p.m.), observed the sun at an altitude of about 25° of a dull red colour, with all its rays apparently drawn together and forming a pillar of light reaching from the sun down to the horizon, and about the sun's diameter in breadth." Mr. Manning told me that of all the curious sights he had seen at sea none had been so impressed on his mind as this sun pillar.

These are instances of continuous pillars from the sun upwards and downwards, one showing the half furthest from the sun only. HY. HARRIES.

Rosebank, Hounslow, September 28.

## THE REPORT OF THE KRAKATÃO COMMITTEE OF THE ROYAL SOCIETY.[1]

### II.

AN appendix to Prof. Judd's section on the geological aspects of the eruption embraces a series of data collected by Dr. Meldrum, F.R.S., of Mauritius, regarding the falls of dust and the occurrence of masses of pumice throughout the Indian Ocean in 1883–84, which he had already communicated to the British Association in 1885. Mr. Scott's prefatory note thereon shows that while such data are of value in exhibiting the immense magnitude of the eruption they cannot help to throw much fresh light upon the question of the Indian superficial oceanic circulation, since the pumice was evidently affected almost as much by the motion of the air as by that of the water. Thus, while a comparison of the two maps reveals a general westerly drift in the direction of the well-known left-handed circulatory system of the Southern Indian Ocean, a detached phalanx of pumice masses off the north-west coast of Australia in 1884 (in the second map) shows, as Mr. Scott observes, a probable drift thither "before the north-west monsoon which would prevail in those seas from November 1883 to March 1884."

In one other point, however, apart from their general interest, these data are valuable in confirming the general westerly trend of all the ejecta at the time of the eruption—a fact whose significance becomes subsequently so marked when dealing with the spread of the optical phenomena.

In the plates of geological sections which are appended to this Part attention should be paid to (3) (4) (5) (6) of Plate 4, in which natural and artificial pumice and dust from Krakatão are compared, since they have an important bearing on Prof. Judd's conclusions.

Part II. of the Report, which deals with the air waves and sounds caused by the principal eruption of Krakatão on August 26 and 27, was prepared, under the direction of Lieut.-General Strachey, F.R.S., principally by Mr. R. H. Curtis, of the Meteorological Office.

The air-waves, as apart from actual sounds, were one of the most extraordinary features of this unique out-

[1] Continued from p. 542.

burst; for, while it is possible that similar waves were propagated through the atmosphere during great eruptions in former years, these appear to be the only instances recorded of anything of the kind on such a vast scale since the establishment of continuous self-recording barometers.

That air-waves caused by the sudden expansion of the erupting gases could leave a perceptible record on all the barometer traces as far as the antipodes of Krakatão, is of itself a sufficiently remarkable fact, but that such waves could record their passage back and forwards no less than seven times, is a circumstance which even now, five years after its occurrence, fills us with astonishment. A selection of forty-seven stations has been made, which, as far as possible, represent the habitable world; and the times of passage of the wave from Krakatão to the antipodes and from the latter back to Krakatão have been deduced by comparing the significant, and in many cases similarly-shaped, notches in the barometer traces.

Of course, where, as in the present case, the form of the wave itself was complicated, gradually became deformed, and was traceable for no less than 127 hours from its commencement, perfect accuracy in determining the precise moments of passage of the various phases could scarcely be expected. Yet it is evident on the face of it that a very high degree of accuracy has been attained, by which not only can the precise moment of the great outburst be determined by the simple process of calculating backwards, but also certain variations of velocity be traced in portions of the wave which took different routes over the globe.

The general pace at which the air-wave spread outwards in concentric circles from Krakatão as a centre, was 700 miles per hour, which is slightly less than the velocity of sound at zero Fahrenheit, viz. 723 miles. The entire circuit of the globe and back was thus made in about thirty-six hours. Also, by a careful comparison of times and probable errors, the probable moment of *the greatest explosion* is calculated to have been 2h. 56m. G.M.T., or 9h. 58m. local time, on the morning of August 27.[1]

This great explosion appears to have been not only the culminating point of the Krakatão eruption (the preceding minor outbursts appearing as a mere roughening of the barometer scale, or a series of moderate oscillations on that of the gasometer at Batavia), but owing to its surpassing intensity, a feature *altogether peculiar to this eruption*, and one by which it will always be distinguished from others, such as that of Asama (Japan) and Skaptar Jokull in 1783, or Tamboro in 1815, which, in respect of the amount of material ejected in the form of lava, and other effects, appear to have equalled if not exceeded it.

One of the most interesting results of this discussion of the Krakatão air-wave has been the discovery of its variation of speed according as it travelled *with* or *against* the earth's rotation. As a general fact it may be said that such variation is plainly traceable to the prevalent drift of the winds.

Thus in the extra-tropics the wave moving from west to east was accelerated, and that from east to west retarded, by about 14 *miles* per hour; while within the tropics the wave which passed through Mauritius and Loanda was affected in a precisely reverse manner, the passage eastwards being retarded, while that westwards was comparatively unaffected, the amount corresponding to an east to west wind of about 10 *miles* an hour. It is at least curious to notice, that on p. 35 of the "Motions of Solids and Fluids," by Prof. Ferrel (Washington, 1882), the value of the due E. to W. component of the trades between 15° N. and S. lat. is given as 10 *miles* per hour, while the mean of the W. to E. component of the anti-trades for latitude 45° at the earth's surface and a height of 3 miles above it, is exactly 14½ *miles* per hour.

[1] This differs by only 4 minutes from 10h. 2m., the epoch determined from fewer data by M. Verbeek.

The greatest general retardation took place in the Southern Ocean, possibly owing to the low temperature of the southern hemisphere in August. All these points are very distinctly shown in the diagrams.

As regards the actual sounds, the facts are without precedent. The unvarnished record reads like a fairy tale. When we are told that at distances of over 2000 miles from the volcano, the noise was like the firing of heavy guns, and that at numerous points of the Indian Ocean steamers were despatched in search of supposed vessels in distress, we are prepared to accept with less hestitation the numerous other collateral evidences of the enormous explosive energy which generated them.

The area over which the sounds were heard is roughly estimated at *one-thirteenth* of the entire surface of the globe. In other words, it was nearly equal to Europe and Africa together, or slightly exceeded that of both Americas. All these details are illustrated by numerous diagrams.

Part III., by Captain W. J. L. Wharton, R.N., F.R.S., deals with the so-called seismic sea waves generated during the eruption; one of which not only dealt death and destruction all over the Straits of Sunda, but travelled as far as Cape Horn, and possibly the English Channel.

It appears that there were two sorts of waves generated—one of long period (two hours), which alone recorded itself on the automatic gauges and travelled to great distances; and others of much shorter period, which were mostly confined to the immediate vicinity of the volcano.

The only hypothesis by which the facts can be reconciled, according to Captain Wharton, is that at the time of the greatest explosion, at 10 o'clock on August 27, "waves of both characters would be more or less synchronously formed," the longer wave being caused by upheaval, and the shorter ones, which caused the destructive effects in the Straits of Sunda, by the displacement due to ejected masses or fragments of the volcano falling into the sea all round it.

In proof of upheaval, which appears to be the only probable cause of the longer wave, Captain Wharton cites the generally shallowed condition of the sea immediately surrounding Krakatão, especially on the northern side.

We cannot, however, help observing that, according to Prof. Judd, the geological evidence is entirely against upheaval throughout the area; and the formation of the new shoals and islands is attributed by him *solely* to the piling up on the sea floor of the coarser matter, including the framework of the volcano, which was ejected during the explosive outbursts. It is a remarkable fact, indeed, that during the eruption there was no trace of any local seismic disturbance such as might be supposed to accompany an upheaval of the ground. A variety of peculiar effects were witnessed, such as clocks stopped, lamps broken, and houses cracked, but all of these were traceable to air and not earth vibrations.

The precise cause, therefore, of the long wave will, as Captain Wharton says, "ever remain to a great extent uncertain." One fact, however, remains clear—that both it and its minor predecessors were distinctly connected with corresponding explosions from the crater, which recorded themselves in unmistakable language on the gasometer pressure-gauge at Batavia. Whatever the precise proximate cause, therefore—whether slow upheaval, according to Captain Wharton, or the impact of falling matter, according to Prof. Judd—the action *commenced* with each explosion.

The height of the local manifestation of the great wave at 10 o'clock is estimated to have been 50 feet, though in places where it reached the shore it appears to have run up to 70 feet.

The terribly destructive effects of these shorter "super-seismic" waves, of which this one appears to have been the greatest, are amply detailed in M. Verbeek's Report, and the accompanying views of the localities visited. They reached the above majestic height only in the

immediate vicinity of the volcano, rapidly falling off in size at a comparatively short distance from the Sunda Straits.

The longer waves, with the original period of two hours, are traced by automatic and eye observations to have proceeded mainly in a westerly direction from Krakatão, being noticeable at Ceylon, all over the western part of the Indian Ocean, the south coasts of Africa and South America, the west coast of Australia, and possibly—though the evidence is not free from doubt—as far as the west coast of France and the entrance to the English Channel. In other directions, such as the China Sea, the Pacific, and the Gulf of Mexico, they do not seem to have been felt, the supposed indications not being compatible in any way with the times and distances.

As a general result, it may be said that the mean depths deduced by the formula $V = \sqrt{gh}$, from the best data for the speed of the waves, corresponded fairly with that given by the soundings, but in nearly every case the formula gave a smaller depth than the soundings. This and other circumstances lead us to conclude, not so much that the formula is incorrect, but that, with so few, and in some cases such badly placed, automatic gauges, and from such complex oscillations as seem to have occurred in many of those discussed in this section, it is scarcely possible to arrive at anything but a very rough approximation to the mean depths. The shelving of the bottom near land, which in many cases is not well determined, and the possible existence of ridges in mid-ocean, constitute obstacles to a determination of mean depth, which is all the passage of such waves can indicate. In so far, however, as they yield an approximate check of this kind on soundings, their observation ought to be encouraged by the establishment of more automatic gauges in suitable spots.

One very peculiar feature of the Krakatão long waves is that, while their original period when leaving Krakatão was two hours, they became subdivided (possibly by an interpolated series caused by reflection from the coast of Java) into waves of half this period; and, by the time they reached the North Atlantic, into waves of about one-quarter of this period. Their consecutive oscillations could thus only be identified with those of the original oscillations by doubling or quadrupling the observed periods.

Although at great distances from Krakatão the height of the largest long wave was, as might be expected, only a few inches; at such comparatively remote places through the more open route to the west as Ceylon and Mauritius, the higher and shorter waves made their presence felt to heights of several feet, and created considerable astonishment as well as damage in these localities.

Like the air and sound waves, the occurrence of seismic waves on such a scale and over such a wide area appears to have been quite unprecedented; and their discussion, like that of the former, will in the present case probably yield results of considerable value to hydrography as well as other branches of science.

(*To be continued.*)

## *FOUNDATIONS OF CORAL REEFS.*

THE following extract from a letter from Captain Aldrich, R.N., H.M. surveying-ship *Egeria*, now employed in the Pacific Ocean, is interesting from several points of view.

"... . The following morning at daylight (July 10) we picked up 268 fathoms (volcanic rock) some considerable distance southward of the Pelorus Reef. This, again, will involve a further search. Twelves miles to the northward the depth was 444, and two subsequent soundings at five-mile intervals gave 713 (ooze) and 888 (ooze). From here the soundings continued to grow shoaler, until in lat. 22° 51′ S., long. 176° 26′ W., we sounded in 335 fathoms (cinder), being close to the assigned position of the Pelorus Reef. The water deepened again to 719 (cinder), when we hove to for the night. On July 11 we continued about this position, the shoalest sounding being 246. On the 12th we continued the search, and by following up at quarter-mile intervals struck 95 fathoms late in the afternoon. Prepared a beacon, and the following day (July 13), after excellent star observations, sounded and shoaled as yesterday, and when the men were standing by to slip the beacon, discoloured water was reported from the mast-head; it was almost immediately seen from the deck, and by 9 a.m. the beacon was dropped in 24 fathoms, with a stretch of light-greenish water extending in a northerly and southerly direction for about half a mile. The whalers were lowered, and remained all day in this green water.

"Meantime more discoloured water was reported from aloft, and I sent Mr. Kiddle up with his glasses, and he verified the report; so, leaving the boats on the Pelorus, I went with the ship, and, after going two miles, I made out the small streak from the poop. It had remained as steady as possible, and had every appearance of being a very small shoal. The ship was taken to within 100 yards of it, and the dingy lowered to get a sounding on it; no bottom, however, could be got, so the ship was put in the middle of it and a sounding of 150 (no bottom) obtained. A bucket of this water was drawn and a bottle of it preserved, but I do not see anything in it to account for the light greenish colour, and it may be that the colouring matter may not lie actually on the surface; the fact remains, that this small patch was sighted at very nearly three miles distance from aloft, and that even when within 100 yards of it I believed it to be shoal-water, and that a sounding of 150 (no bottom) was actually obtained in the middle of it. On our return to the Pelorus, I was not, therefore, much astonished when I found that no very shoal water had been got by the boats. The ship was anchored in 14 fathoms, not far from the beacon, and the wire machines put into the whalers, and a search on bearings from the standard compass and mast-head angles carried on during the afternoon and on the next day, July 14. Nothing less than 14, however, was got, and I am under the impression that nothing less is to be met with, as the bottoms are loose ashes and cinder; so that, as in the case of the Graham Shoal, there may have been a shoal quite recently which does not exist now. I think that had there been anything dangerous about it we should have seen it, as anchoring in 14 fathoms mid-ocean caused many inquiring eyes to be cast around. . . . .

"Another curious thing about the greenish water is that I went over it all in the ship; and the line between it and the dark water was most distinct. Moreover, the shoalest sounding of 14 fathoms was not found in the light water, but in the dark water alongside it. There was no sign of coral among the bottoms brought up. . . . My attention was pretty well occupied at this time, and it did not occur to me to do more than have a bucket of the water drawn from the green colour to preserve, which has been done. Afterwards, I much regretted that I did not get specimens from different depths, as certainly this is a most curious instance of, in one case, picking up a shoal from the existence of some colouring matter, not coral; and, in the other, of being almost positive that a shoal existed where an actual sounding proved it not to do so. I can quite excuse a man reporting a shoal under such circumstances, and it may be that a good many of the reported dangers have come on the charts in this way. . ."

The position of the Pelorus Reef referred to is in lat. 23° S., long. 176° 25′ W., about forty miles south of Pylstaart Island, which is volcanic. The reef was originally reported in 1861 by H.M.S. *Pelorus*, Commodore Seymour (now Lord Alcester), the ship passing within one-third of a mile of it, when breakers were distinctly seen.

Lord Alcester assures me that there was no doubt of the breakers, otherwise it might be thought that the deceptive appearance that misled Captain Aldrich, also misled the officers of the *Pelorus*.

It thus appears probable that, as in some other cases (of which the Graham Island in the Mediterranean is perhaps best known), the cinders and ashes which formed, and still form, the summit of the volcanic mound originally thrown up, are being by wave-action gradually swept away, and will continue to be so removed until the top of the bank is reduced below the limit of such action, or, as in the case of the Graham Shoal, the solid rock is laid bare.

If so, it is another case of the preparation of a suitable foundation for coral builders by a process directly the reverse of that of building up by marine organisms on mounds that have failed to reach the surface, suggested by Mr. John Murray to be the principal method.

It remains for those who have made submarine eruptions their study to say whether a mound raised in the sea is covered with loose matter in a sufficient percentage of cases to justify this mode of coral-foundation-making being given an important place amongst others.

In the latest known cases of islands so formed, viz. Steers and Calmeyer Islands, thrown up near Krakatão in 1883, and Falcon Island, which appeared in 1885 in the Tonga Group, the surface structure was loose. The two former very shortly disappeared below the level of the sea. What is happening to the latter is not known, as it is seldom sighted; but from its volume and height (290 feet) the process of reduction, even if no compact nucleus exists above water, must be slow.

The deceptive appearance of the masses of minute organisms which floated in the vicinity of the bank is no doubt an abundant source of false reports. These clouds of matter are commoner in inclosed and calmer waters, like the Red Sea, than in open oceans, where they are so much more liable to be dispersed by the waves before they can accumulate to any size. The assistance they afforded in this instance to the searchers is remarkable, and so far as I know unique, as they are generally found in deep water. W. J. L. WHARTON.

## *RECENT VISIT OF NATURALISTS TO THE GALAPAGOS.*

CAPTAIN J. M. DOW has placed at my disposal the subjoined short account of a visit recently paid to the Galapagos Group by the United States steamer *Albatross*, which will, I am sure, be of much interest to naturalists. P. L. SCLATER.

*U.S. Commission of Fish and Fisheries,*
*Steamer "Albatross," Acapulco, Mexico,*
*April* 24, 1888.

CAPTAIN J. M. DOW, *Panama*.

MY DEAR SIR,—Thinking that you might like to know something of the results of our trip to the Galapagos, I take this opportunity of writing.

Leaving Panama on the morning of March 30, we made during that day six hauls of the trawl in depths from 7 to 51 fathoms. These gave us fine results, including many species with which you are doubtless familiar. The fishes included species of *Upeneis, Arius, Polynemus, Aphronitia, Serranus, Selene, Prionotus, Hæmulon, Synodus, Tetrodon, Ophidium, Sciæna, Micropogon, Lophius*. We were delighted to see *Thalasophryne* and two allied species. The number of shells, Crustacea, &c., was almost innumerable. The care of so much material kept us very busy. The next day we sounded off Cape Mala, and found the depth to be 1927 fathoms. No more dredging was done until we neared the Galapagos on April 3, when we made a haul in 1379 fathoms, where the amount of material obtained was small, although it included some very good things. At the islands we made visits to eight of the principal ones, Most of our days were spent on shore, beginning early in the morning, and oftentimes bird-skinning and other work was prolonged far into the night. The islands presented a very inhospitable look along the shores, with the black lava cropping about everywhere; but in two of them (Chatham Island and Charles Island) the interior was extremely fertile and pleasant. Collecting was always difficult; but, with the co-operation of officers and men, we obtained a great quantity of material. We naturally looked to the birds first, on account of Darwin's previous work there. We have over 250 good bird-skins, besides several hundred specimens in alcohol, and a few skeletons. Of the fifty-seven species before reported from there, we obtained examples of fifty or more, and we have, in addition, several which are apparently new to science. We hope, with our material, to settle some of the curious problems of these islands.

We secured specimens of all the reptiles which have been before found there, and also hope that we have two or three new lizards. The tortoises excited great interest, and it would please you to see the many large ones which are now crawling about our decks. We expect now that we shall be able to raise them in the States.

Fishing was good at all of our anchorages, and we all had sport in catching fishes over the ship's side. We got between thirty and forty species in all, including a large brown "grouper," which is there caught and salted for the Ecuador market.

One night, while running from one island to another, we stopped and drifted for a while, and put the electric light over the side. Besides many small things, large sharks came around in great numbers. More than twenty were seen at once, and I know that the sight would have pleased you. We all regretted that you were not with us. Notwithstanding the necessity for rapid work, good-fellowship always prevailed as usual. I hope that some time you may take a trip with me on the *Albatross*, and see how we do it.

Hoping that this will not prove too long an account for you,

I remain,
Yours very sincerely,
LESLIE A. LEE.

## *THE BRITISH ASSOCIATION.*

SECTION A—MATHEMATICAL AND PHYSICAL SCIENCE.

*A Simple Hypothesis for Electro-magnetic Induction of Incomplete Circuits; with Consequent Equations of Electric Motion in Fixed Homogeneous or Heterogeneous Solid Matter*, by Sir William Thomson.

(1) To avoid mathematical formulas till needed for calculation consider three cases of liquid [1] motion which for brevity I call Primary, Secondary, Tertiary, defined as follows:—Half the velocity in the Secondary agrees numerically and directionally with the magnitude and axis of the molecular spin at the corresponding point of the Primary; or (short, but complete, statement) *the half velocity in the Secondary is the spin in the Primary, and (similarly) half the velocity in the Tertiary is the spin in the Secondary.*

(2) In the Secondary and Tertiary the motion is essentially without change of density, and in each of them we naturally, therefore, take an incompressible fluid as the substance. The motion in the Primary we arbitrarily restrict by taking its fluid also as incompressible.

(3) Helmholtz first solved the problem—Given the spin in any case of liquid motion, to find the motion. His solution consists in finding the potentials of three ideal distributions of gravitational matter having densities respectively equal to $1/4\pi$ of the rectangular components of the given spin; and, regarding

[1] I use "liquid" for brevity to signify incompressible fluid.

for a moment these potentials as rectangular components of velocity in a case of liquid motion, taking the spin in this motion as the velocity in the required motion. Applying this solution to find the velocity in our Secondary from the velocity in our Tertiary, we see that the three velocity components in our Primary are the potentials of three ideal distributions of gravitational matter having their densities respectively equal to $1/4\pi$ of the three velocity components of our Tertiary. This proposition is proved in a moment,[1] in § 5 below, by expressing the velocity components of our Tertiary in terms of those of our Secondary, and those of our Secondary in terms of those of our Primary; and then eliminating the velocity components of Secondary, so as to have those of Tertiary directly in terms of those of Primary.

(4) Consider now, in a fixed solid or solids of no magnetic susceptibility, any case of electric motion in which there is no change of electrification, and therefore no incomplete electric circuit, or, which is the same, any case of electric motion in which the distribution of electric current agrees with the distribution of velocity in a case of liquid motion. Let this case, with velocity of liquid numerically equal to $4\pi$ times the electric current density, be our Tertiary. The velocity in our corresponding Secondary is then the magnetic force of the electric current system;[2] and the velocity in our Primary is what Maxwell[3] has well called the "electro-magnetic momentum at any point" of the electric current system; and the rate of decrease per unit of time, of any component of this last velocity at any point, is the corresponding component of electromotive force, due to electro-magnetic induction of the electric current system when it experiences any change. This electromotive force, combined with the electrostatic force, if there is any, constitutes the whole electromotive force at any point of the system. Hence by Ohm's law each component of electric current at any point is equal to the electric conductivity multiplied into the sum of the corresponding component of electrostatic force and the rate of decrease per unit of time of the corresponding component of velocity of liquid in our Primary.

(5) To express all this in symbols, let $(u_1, v_1, w_1)$, $(u_2, v_2, w_2)$, and $(u_3, v_3, w_3)$ denote rectangular components of the velocity at time $t$, and point $(x, y, z)$ of our Primary, Secondary, and Tertiary. We have (§ 1)—

$$u_2 = \frac{dw_1}{dy} - \frac{dv_1}{dz}, \quad v_2 = \frac{du_1}{dz} - \frac{dw_1}{dx}, \quad w_2 = \frac{dv_1}{dx} - \frac{du_1}{dy} \,. \quad (1)$$

$$u_3 = \frac{dw_2}{dy} - \frac{dv_2}{dz}, \quad v_3 = \frac{du_2}{dz} - \frac{dw_2}{dx}, \quad w_3 = \frac{dv_2}{dx} - \frac{du_2}{dy} \,. \quad (2)$$

Eliminating $u_2, v_2, w_2$ from (2) by (1), we find—

$$u_3 = \frac{d}{dx}\left(\frac{du_1}{dx} + \frac{dv_1}{dy} + \frac{dw_1}{dz}\right) - \left(\frac{d^2u_1}{dx^2} + \frac{d^2u_1}{dy^2} + \frac{d^2u_1}{dz^2}\right); \text{ \&c.} \quad \ldots \quad (3)$$

But, by our assumption (§ 2) of incompressibility in the Primary—

$$\frac{du_1}{dx} + \frac{dv_1}{dy} + \frac{dw_1}{dz} = 0 \quad \ldots\ldots\ldots \quad (4)$$

Hence (3) becomes—

$$u_3 = -\nabla^2 u_1, \quad v_3 = -\nabla^2 v_1, \quad w_3 = -\nabla^2 w_1 \quad \ldots \quad (5)$$

where, as in Article xxvii. (November 1846) of my "Collected Papers" (vol. i.)—

$$\nabla^2 = \frac{d^2}{dx^2} + \frac{d^2}{dy^2} + \frac{d^2}{dz^2} \quad \ldots\ldots\ldots \quad (6)$$ [4]

This (5) is the promised proof of § 3.

(6) Let now $u, v, w$ denote the components of electric current at $(x, y, z)$ in the electric system of § 4; so that—

$$4\pi u = u_3 = -\nabla^2 u_1; \; 4\pi v = v_3 = -\nabla^2 v_1; \; 4\pi w = w_3 = -\nabla^2 w_1 \,. \quad (7)$$

which, in virtue of (4), give—

$$\frac{du}{dx} + \frac{dv}{dy} + \frac{dw}{dz} = 0 \quad \ldots\ldots\ldots \quad (8)$$

[1] From Poisson's well-known elementary theorem, $\nabla^2 V = -4\pi\rho$.

[2] "Electrostatics and Magnetism," § 517 (Postscript) (c).

[3] "Electricity and Magnetism," §§ 585, 604.

[4] Maxwell, for quaternionic reasons, takes $\nabla^2$ the negative of mine.

Hence the components of electromotive force due to change of current, being, (§ 5)—

$$-\frac{du_3}{dt}, \; -\frac{dv_3}{dt}, \; -\frac{dw_3}{dt},$$

are equal to—

$$4\pi\nabla^{-2}\frac{du}{dt}, \; 4\pi\nabla^{-2}\frac{dv}{dt}, \; 4\pi\nabla^{-2}\frac{dw}{dt} \quad \ldots\ldots \quad (9)$$

and therefore if $\Psi$ denote electrostatic potential, we have, for the equations of the electric motion (§ 5)—

$$u = \frac{1}{\kappa}\left(\nabla^{-2}\frac{du}{dt} - \frac{d\Psi}{dx}\right); \; v = \frac{1}{\kappa}\left(\nabla^{-2}\frac{dv}{dt} - \frac{d\Psi}{dy}\right);$$

$$w = \frac{1}{\kappa}\left(\nabla^{-2}\frac{dw}{dt} - \frac{d\Psi}{dz}\right) \quad \ldots\ldots\ldots \quad (10)$$

where $\kappa$ denotes $1/4\pi$ of the specific resistance.

(7) As $\Psi$ is independent of $t$, according to § 4, we may, conveniently for a moment, put—

$$u + \frac{d\Psi}{\kappa dx} = \alpha; \; v + \frac{d\Psi}{\kappa dy} = \beta; \; w + \frac{d\Psi}{\kappa dz} = \gamma \quad \ldots \quad (11)$$

and so find, as equivalents to (9)—

$$\frac{d\alpha}{dt} = \nabla^2(\kappa\alpha); \; \frac{d\beta}{dt} = \nabla^2(\kappa\beta); \; \frac{d\gamma}{dt} = \nabla^2(\kappa\gamma) \quad \ldots \quad (12)$$

The interpretation of this elimination of $\Psi$ may be illustrated by considering for example a finite portion of *homogeneous* solid conductor, of any shape (a long thin wire with two ends, or a short thick wire, or a solid globe, or a lump of any shape, of copper or other metal homogeneous throughout) with a constant flow of electricity maintained through it by electrodes from a voltaic battery or other source of electric energy, and with proper appliances over its whole boundary, so regulated as to keep any given constant potential at every point of the boundary; while currents are caused to circulate through the interior by varying currents in circuits exterior to it. There being no *changing electrification* by our supposition of § 4, $\Psi$ can have no contribution from electrification within our conductor; and therefore, throughout our field—

$$\nabla^2\Psi = 0 \quad \ldots\ldots\ldots \quad (13)$$

which, with (8) and (11), gives—

$$\frac{d\alpha}{dx} + \frac{d\beta}{dy} + \frac{d\gamma}{dz} = 0 \quad \ldots\ldots\ldots \quad (14)$$

Between (12) and (14) we have four equations for three unknown quantities. These, *in the case of homogeneousness* ($\kappa$ constant), are equivalent to only three, because in this case (14) follows from (12) provided (14) is satisfied initially, and proper surface condition is maintained to prevent any violation of it from supervening. But unless $\kappa$ is constant throughout our field, the four equations (12) and (14) are mutually inconsistent; from which it follows that our supposition of unchangingness of electrification (§ 4) is not generally true. An interesting and important practical conclusion is, that when currents are induced in any way, in a solid composed of parts having different electric conductivities (pieces of copper and lead, for example, fixed together in metallic contact), there must in general be changing electrification over every interface between these parts. This conclusion was not at first obvious to me; but it ought to be so by anyone approaching the subject with mind undisturbed by mathematical formulas.

(8) Being thus warned off heterogeneousness until we come to consider changing electrification and incomplete circuits, let us apply (10) to an infinite homogeneous solid. As (8) holds through all space according to our supposition in § 4, and as $\kappa$ is constant, (13) must now hold through all space, and therefore $\Psi = 0$, which reduces (10) to—

$$u = \frac{1}{\kappa}\nabla^{-2}\frac{du}{dt}; \; v = \frac{1}{\kappa}\nabla^{-2}\frac{dv}{dt}; \; w = \frac{1}{\kappa}\nabla^{-2}\frac{dw}{dt} \quad \ldots \quad (15)$$

These equations express simply the known law of *electro magnetic* induction. Maxwell's equations (7) of § 783 of his "Electricity and Magnetism," become, in this case—

$$\mu\left(4\pi C + K\frac{d}{dt}\right)\frac{du}{dt} = \nabla^2 u, \text{ \&c.} \quad \ldots\ldots \quad (15')$$

which cannot be right, I think (???), according to any conceivable hypothesis regarding electric conductivity, whether of metals, or

stones, or gums, or resins, or wax, or shell-lac, or gutta-percha, or india-rubber, or glasses, or solid or liquid electrolytes; being, as seems (?) to me, vitiated for complete circuits, by the curious and ingenious, but, as seems to me, not wholly tenable, hypothesis which he introduces, in § 610, for incomplete circuits.

(9) The hypothesis which I suggest for incomplete circuits and consequently varying electrification, is simply that the components of the electromotive due to electro-magnetic induction are still $4\pi\nabla^{-2}du/dt$, &c. Thus for the equations of motion we have simply to keep equations (10) unchanged, while not imposing (8), but instead of it taking—

$$\text{"}v\text{"}^2\left(\frac{du}{dx}+\frac{dv}{dy}+\frac{dw}{dz}\right)=\frac{d}{dt}\nabla^2\Psi \quad . \quad . \quad . \quad . \quad . \quad (16)$$

where "$v$" denotes the number of electrostatic units in the electro-magnetic unit of electric quantity. This equation expresses that the electrification of which $\Psi$ is the potential increases and diminishes in any place according as electricity flows more out than in, or more in than out. We thus have four equations (10) and (16) for our four unknowns, $u$, $v$, $w$, $\Psi$; and I find simple and natural solutions with nothing vague, or difficult to understand, or to believe when understood, by their application to practical problems, or to conceivable ideal problems; such as the transmission of ordinary or telephonic signals along submarine telegraph conductors and land-lines, electric oscillations in a finite insulated conductor of any form, transference of electricity through an infinite solid, &c. This, however, does not prove my hypothesis. Experiment is required for informing us as to the real electro-magnetic effects of incomplete circuits, and as Helmholtz has remarked, it is not easy to imagine any kind of experiment which could decide between different hypotheses which may occur to anyone trying to evolve out of his inner consciousness a theory of the mutual force and induction between incomplete circuits.

*On the Transference of Electricity within a Homogeneous Solid Conductor*, by Sir William Thomson.—Adopting the notation and formulas of my previous paper, and taking $\rho$ to denote $4\pi$ times the electric density at time $t$, and place $(x, y, z)$, we have—

$$\rho=\nabla^2\Psi=-\text{"}v\text{"}^2\int\left(\frac{du}{dx}+\frac{dv}{dy}+\frac{dw}{dz}\right)dt \quad . \quad . \quad (17)$$

and, eliminating $u$, $v$, $w$, $\Psi$ by this and (16) from (10), we find, on the assumption of $\kappa$ constant—

$$\kappa\frac{d}{dt}\nabla^2\rho=\frac{d^2\rho}{dt^2}-\text{"}v\text{"}^2\nabla^2\rho \quad . \quad . \quad . \quad . \quad . \quad (18)$$

The settlement of boundary conditions, when a finite piece of solid conductor is the subject, involves consideration of $u$, $v$, $w$, and for it, therefore, equations (17) and (12) must be taken into account; but when the subject is an infinite homogeneous solid, which, for simplicity, we now suppose it to be, (18) suffices. It is interesting and helpful to remark that this agrees with the equation for the density of a viscous elastic fluid, found from Stokes's equations for sound in air with viscosity taken into account; and that the values of $u$, $v$, $w$, given by (17) and (10), when $\rho$ has been determined, agree with the velocity components of the elastic fluid if the simple and natural enough supposition be made that viscous resistance acts only against change of shape, and not against change of volume without change of shape.

For a type-solution assume—

$$\rho=AE^{-qt}\cos\frac{2\pi x}{a}\cos\frac{2\pi y}{b}\cos\frac{2\pi z}{c} \quad . \quad . \quad . \quad . \quad (19)$$

and we find, by substitution in (18)—

$$q^2-\frac{\kappa}{L^2}q+\frac{\text{"}v\text{"}^2}{L^2}=0 \quad . \quad . \quad . \quad . \quad . \quad . \quad (20)$$

where—

$$L^2=14\Big/\pi^2\left(\frac{1}{a^2}+\frac{1}{b^2}+\frac{1}{c^2}\right) \quad . \quad . \quad . \quad . \quad . \quad (21)$$

Hence, by solution of the quadratic (20) for $q$—

$$q=\tfrac{1}{2}\frac{\kappa}{L^2}\left\{1\pm\sqrt{\left(1-4\frac{\text{"}v\text{"}^2L^2}{\kappa^2}\right)}\right\} \quad . \quad . \quad (22)$$

[In the communication to the Section numerical illustrations of non-oscillatory and of oscillatory discharge are given.]

*Five Applications of Fourier's Law of Diffusion, illustrated by a Diagram of Curves with Absolute Numerical Values*, by Sir William Thomson.—(1) Motion of a viscous fluid; (2) closed electric currents within a homogeneous conductor;[1] (3) heat; (4) substances in solution; (5) electric potential in the conductor of a submarine cable when electro-magnetic inertia can be neglected.[2]

1. Fourier's now well-known analysis of what he calls the "linear motion of heat" is applicable to every case of diffusion in which the substance concerned is in the same condition at all points of any one plane parallel to a given plane. The differential equation of diffusion,[3] for the case of constant diffusivity, $\kappa$, is—

$$\frac{dv}{dt}=\kappa\frac{d^2v}{dx^2},$$

where $v$ denotes the "*quality*" at time $t$ and at distance $x$ from a fixed plane of reference. This equation, stated in words, is as follows:—Rate of augmentation of the "*quality*" per unit of time is equal to the diffusivity multiplied into the rate of augmentation per unit of space of the "*quality*."

The meaning of the word "*quality*" here depends on the subject of the diffusion, which may be any one of the five cases referred to in the title above.

2. If the subject is motion of a viscous fluid, the "*quality*" is any one of three components of the velocity, relative to rectangular rectilineal co-ordinates. But in order that Fourier's diffusional law may be applicable, we must either have the motion very slow, according to a special definition of slowness; or the motion must be such that the velocity is the same for all points in the same stream-line, and would continue to be steadily so if viscosity were annulled at any instant. This condition is satisfied in laminar flow, and more generally in every case in which the stream-lines are parallel straight lines. It is also satisfied in the still more general case of stream-lines coaxal circles with velocity the same at all points at the same distance from the axis. Our present illustration, however, is confined to the case of laminar flow, to which Fourier's diffusional laws for what he calls "linear motion" (as explained above in § 1) is obviously applicable without any limitation to the greatness of the velocity in any part of the fluid considered (though with conceivably a reservation in respect to the question of stability[4]). In this case the "*quality*" is simply fluid velocity.

3. If the subject is electric current in a non-magnetic metal, with stream-lines parallel straight lines, the "*quality*" is simply current-density, that is to say, strength of current per unit of area perpendicular to the current. The perfect mathematical[5] analogy between the electric motion thus defined, and the corresponding motion of a viscous fluid defined in § 2 was accentuated by Mr. Oliver Heaviside in the *Electrician*, July 12, 1884; and in the following words in the *Philosophical Magazine* for 1886, second half-year, p. 135:—"Water in a round pipe is started from rest and set into a state of steady motion by the sudden and continued application of a steady longitudinal dragging or shearing force applied to *its boundary*. This analogue is useful because everyone is familiar with the setting of water in motion by friction on its boundary, transmitted inward by viscosity." Mr. Heaviside well calls this analogue "useful." It is, indeed, a very valuable analogy, not merely in respect to philosophical consideration of electricity, ether, and ponderable matter, but as facilitating many important estimates, particu-

[1] This subject is essentially the "electro-magnetic induction" of Henry and Faraday. It is essentially different from the "diffusion of electricity" through a solid investigated by Ohm in his celebrated paper "Die Galvanische Kette mathematisch bearbeitet," Berlin, 1827; translated in Taylor's "Scientific Memoirs," vol. ii. Part 8, "The Galvanic Circuit investigated Mathematically," by Dr. G. S. Ohm. In Ohm's work electro-magnetic induction is not taken into account, nor does any idea of an electric analogue to inertia appear. The electromotive force considered is simply that due to the difference of electrostatic potential in different parts of the circuit, unsatisfactorily, and even not accurately, explained by what, speaking in his pre-Greenian time, he called "the electroscopic force of the body," and defined or explained as "the force with which the electroscope is repelled or attracted by the body;" the electroscope being "a second movable body of invariable electric condition."

[2] This subject belongs to the Ohmian electric diffusion pure and simple, worked out by aid of Green's theory of the capacity of a Leyden jar (see "Mathematical and Physical Paper," vol. ii. Art. 73).

[3] See "Mathematical and Physical Papers," vol. ii. Art. 72.

[4] See "Stability of Fluid Motion," § 28, *Philosophical Magazine*, August 1887.

[5] It is essentially a mathematical analogy only; in the same sense as the relation between the "uniform motion of heat" and the mathematical theory of electricity, which I gave in the *Cambridge Mathematical Journal* forty-six years ago, and which now constitutes the first article of my "Electrostatics and Magnetism," is a merely mathematical analogy.

larly some relating to telephonic conductors and conductors for electric lighting on the "alternate-current" system. In a short article to be included in vol. iii. of my collected papers, which I hope will soon be published, I intend to describe a generalization, with, as will be seen, a consequently essential modification of this analogy, by which it is extended to include the mutual induction between conductors separated by air or other insulators, and currents in solids of different conductivity fixed together in contact.

4. If the subject is heat, as in Fourier's original development of the theory of diffusion, the "*quality*" is temperature.

5. If the subject is diffusion of matter, the "*quality*" is density of the matter diffused, or deviation of density from some mean or standard density considered. It is to Fick, thirty-three years ago Demonstrator of Anatomy, and now Professor of Physiology in the University of Zürich, that we owe this application of Fourier's diffusional theory, so vitally important in physiological chemistry and physics, and so valuable in natural philosophy generally. When the substance through which the diffusion takes place is fluid, a very complicated but practically important subject is presented if the fluid be stirred. The exceedingly rapid progress of the diffusion produced by vigorous up-and-down-stirring, causing to be done in half a minute the diffusional work which would require years or centuries if the

$$\mathrm{ON} = x$$

$$\mathrm{NP} = y$$

$$y = \frac{2}{\sqrt{\pi}}\int_0^{2x/t} \epsilon^{-q^2} dq.$$

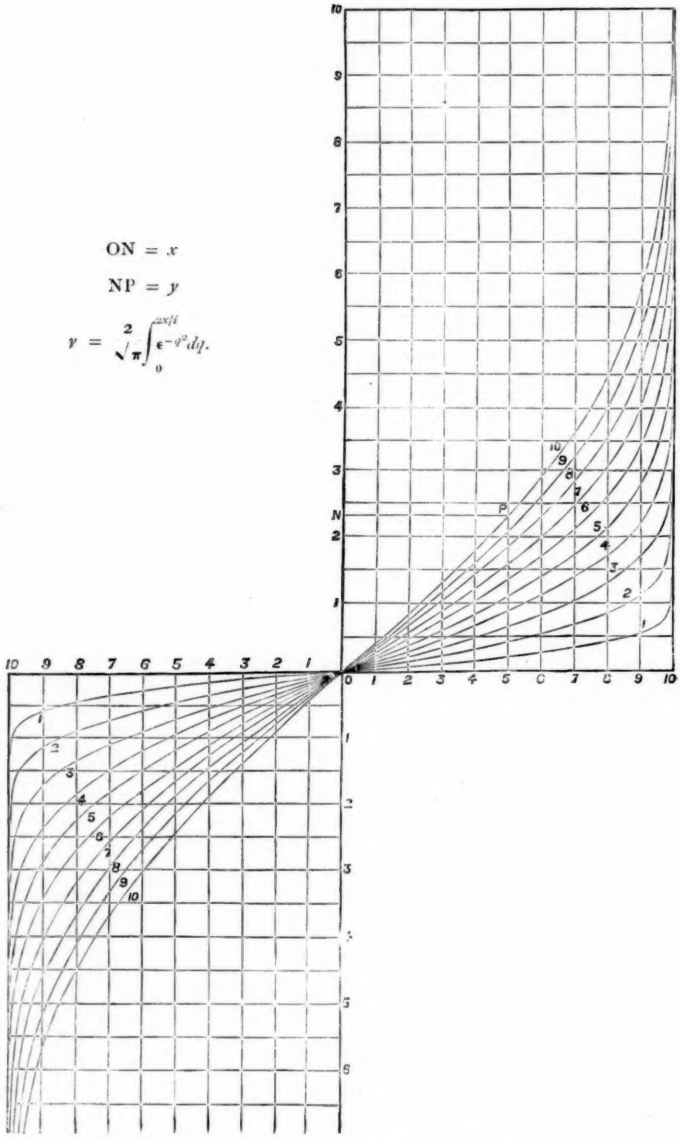


Diagram showing Progress of Laminar Diffusion.

fluid were quiescent, is easily explained; and the explanation is illustrated by the diagram of curves, § 7 below, with the time-values given for sugar and common salt. Look at curve No. 1, and think of the corresponding curve with vertical ordinates diminished in the ratio of 1 to 40. The corresponding diffusion would take place for sugar in 11 seconds, and for salt in $3\frac{1}{2}$ seconds. The case so represented would quite correspond to a streaky distribution of brine and water or of syrup and water, in which portions of greatest and least salinity or saccharinity are within half a millimetre of one another. This is just the condition which we see, in virtue of the difference of optic refractivity produced by difference of salinity or of saccharinity, when we stir a tumbler of water with a quantity of undissolved sugar or salt on its bottom. If water be poured very gently on a quantity of sugar or salt in the bottom of a tumbler with violent stirring up guarded against by a spoon—the now almost extinct Scottish species called "toddy ladle" being the best form, or, better still, a little wooden disk which will float up with the water; and if the tumbler be left to itself undisturbed for two or three weeks, the condition at the end of $17 \times 10^5$ seconds (twenty days) for the case of sugar, or $5{\cdot}4 \times 10^5$ seconds (six days) for salt, will be that represented by No. 10 curve in the diagram.

6. If the subject be electricity in a submarine cable, the "*quality*" is electric potential at any point of the insulated conductor. It is only if the cable were a straight line that $x$ would be (as defined above) distance from a fixed plane: but the cable need not be laid along a straight line; and the proper definition of $x$ for the application of Fourier's formula to a submarine cable is the distance along the cable from any point of reference (one end of the cable, for example) to any point of the cable. For this case the diffusivity is equal to the conductivity of its conductor, reckoned in electrostatic units, divided by the electrostatic capacity of the conductor per unit length insulated as it is in gutta-percha, with its outer surface wet with sea-water, which, in the circumstances, is to be regarded as a perfect conductor. For demonstration of this proposition see vol. ii. Art. lxxiii. (1855) of my collected papers.

7. *Explanation of Diagram showing Progress of Laminar Diffusion.*—In each curve—

$$\frac{1}{10}NP = \frac{2}{\sqrt{\pi}}\int_0^{2x/i} dq.\epsilon^{-q^2},$$

where $x$ denotes the number of centimetres in $ON$, and $i$ the "curve-number." The curves are drawn directly from the values of the integral given in Table III., appended to De Morgan's article "On the Theory of Probabilities," "Encyclopædia Metropolitana," vol. ii. pp. 483–84.

| | |
|---|---|
| $NP$ denotes the "*quality*" (defined below) | at distance $= ON$ from initia surface or interface, and at time equal in seconds to ["curve-number"]$^2$ divided by sixteen times the diffusivity in square centimetres per second. |

| Subject of Diffusion. | "*Quality*" (represented by $\frac{1}{10}NP$). |
|---|---|
| Motion of a viscous fluid ... | Ratio of the velocity at $N$ to the constant velocity at $O$ |
| Closed electric currents within a homogeneous conductor | Current-density |
| Heat ... ... ... ... ... | Ratio of temperature *minus* mean temperature to mean temperature |
| Substance in solution ... ... | Ratio of density *minus* mean density to mean density |
| Electric potential in the conductor of a submarine cable | Ratio of potential at $N$ to constant potential at end $O$ |

EXAMPLES.

| "Curve-number." | Time in Seconds. | Case of Diffusion. |
|---|---|---|
| 1 | 27056 | Zinc sulphate through water |
| 1 | 25720 | Copper sulphate through water |
| 1 | 17000 | Sugar through water |
| 1 | 5400 | Common salt through water |
| 5 | 1180 | Heat through wood |
| 5 | 118 | Laminar motion of water at 10° C. |
| 5 | 30 | Laminar motion of air |
| 5 | 7·1 | Heat through iron |
| 5 | 1·31 | Heat through copper |
| | | Electric current in a homogeneous non-magnetic conductor: |
| 10 | 0·0488 | Copper |
| 10 | 0·0040 | Lead |
| 10 | 0·0038 | German silver |
| 10 | 0·0023 | Platinoid |
| 1,000,000,000 | 2·15 | Electric potential in the Direct U.S. Atlantic Cable |

Prof. G. H. Darwin sent a paper *On the Mechanical Conditions of a Swarm of Meteorites and on Theories of Cosmogony.*—This is an abstract of a communication made to the Royal Society, in which the author proposes to apply the principles of the kinetic theory of gases to the case of a swarm of meteorites in space. In the author's theory the individual meteorites are considered to be analogous to the molecules of the gas; and thus a swarm of meteorites, in the course of conglomeration into a star, possesses mechanical properties analogous to those of a gas. Lockyer and others have expressed their conviction that the present condition of the solar system is derived from an accretion of meteorites, but the idea of fluid pressure seems necessary for the applicability of any theory like the nebular hypothesis. The author then proposes to reconcile the nebular and meteoric theories by showing that the laws of fluid pressure apply to a swarm of meteorites. The case of a globular swarm of equal-sized meteorites is considered, and then the investigation is extended to the case in which the meteorites are of various sizes; the latter extension does not affect the nature of the proof, and only slightly modifies the result. In the case of a swarm of meteorites condensing under the mutual attraction of its parts, the author shows that the larger meteorites will tend to settle towards the centre of condensation, and that consequently the mean size of the meteorites will decrease from the centre towards the outside of the swarm.

## NOTES.

WE mentioned some time ago that the executors of the late Sir William Siemens, desiring to have his biography authoritatively published, had placed its preparation in the hands of Dr. William Pole, F.R.S., Honorary Secretary of the Institution of Civil Engineers, who had long been a personal friend of Sir William and his family. The work is now finished, and will be published immediately, in one volume, by Mr. Murray. It will be followed by other volumes, containing reprints of Sir William's most important scientific papers, lectures, and addresses, edited by his secretary, Mr. E. F. Bamber.

ALL who take an interest in questions relating to technical education have reason to be grateful to the Goldsmiths' Company for the way in which it has associated itself with the movement for the establishment of technical and recreative institutes in South London. By an act of splendid generosity it has secured that there shall soon be a great centre of technical instruction at New Cross. Subject to the sanction of Parliament, which will of course be readily granted, the following proposal has been accepted. Out of the surplus funds of the

City parochial charities, the Charity Commissioners are to acquire the buildings, with seven acres of land, at present occupied by the Royal Naval School at New Cross; and from the same source they will set apart an endowment of £2500 per annum. This will be met by the Goldsmiths' Company by the appropriation out of their corporate funds (not trust funds, but funds over which they have absolute control) of an annual endowment of a similar amount—a gift equal to a sum of £85,000. It is intended that the new Institute shall be called "The Goldsmiths' Company's (New Cross) Institute."

IT is satisfactory to learn that all the scientific work connected with the Fishery Board for Scotland is now absolutely in the hands of a small Committee, of which Prof. Ewart is convener, and that the Board has at last a scientific secretary. A Special Committee on Bait, appointed by the Secretary for Scotland, began its sittings on Monday.

THE first meeting of the Council of the Sanitary Institute, which has recently been incorporated, was held at the Parkes Museum last Friday. Sir Douglas Galton, K.C.B., F.R.S., was unanimously appointed Chairman of the Council, and Mr. G. J. Symons, F.R.S., the registrar. The Institute is founded to carry on the work of the amalgamated Sanitary Institute of Great Britain and the Parkes Museum, and it was decided to hold the Institute's first examination for local surveyors and inspectors of nuisances on November 8 and 9. A programme of lectures for the winter session is being prepared. A letter was read from the Charity Commissioners saying that they considered that the new Institute was likely to prove a powerful means for the diffusion of sanitary knowledge, and promising to place at its disposal, for the delivery of lectures, the buildings which the Commissioners propose to establish in various parts of London.

THE delegates to the International Bureau of Weights and Measures are hard at work at the Pavillon de Breteuil, near St. Cloud. They are taking steps to verify the "prototype metres" which have been executed at the expense of the French Government, and are to be delivered to the various nations which have ordered them. The expenditure of this establishment, which is supported by contributions from several nations, amounts to £4000. The head of the administration is M. Broch, a Norwegian astronomer and meteorologist. Turkey is nominally one of the subscribing nations, but she has never contributed a farthing to the funds of the Bureau, and some time ago the other nations were obliged to subscribe a supplementary sum to make good the deficiency.

THE School of Art Wood-carving, City and Guilds Institute, Exhibition Road, South Kensington, has been re-opened after the usual summer vacation, and we are requested to state that one or two of the free Studentships in the evening classes maintained by means of funds granted to the school by the Institute are vacant. To bring the benefits of the school within the reach of artisans, a remission of half-fees for the evening class is made to artisan students connected with the wood-carving trade. Forms of application for the free Studentships and any further particulars relating to the school may be obtained from the manager.

TEN lectures on "Electricity in the Service of Man" are to be delivered by Mr. W. Lant Carpenter, under the auspices of the London Society for the Extension of University Teaching, at the Chelsea Town Hall. They will be delivered on Fridays at 8 p.m. The inaugural lecture, on electrical energy and its uses, will be given on October 12, when Sir Henry Roscoe will take the chair.

THE sixth session of University College, Dundee, was opened by a public address by Prof. Ewing in the College Hall last Saturday evening. Prof. Ewing gave an interesting account of the progress which has lately been made in the teaching of science in Dundee.

HERR HERNSHEIM, the German Consul at Matupi, one of the South Sea Islands, has presented his native town, Mayence, with an ethnological collection which gives an interesting picture of the manners, customs, and conditions of life of the inhabitants of the Bismarck Archipelago, and the Caroline, Marshall, Pelew, and Solomon Groups.

TOWARDS the cost of the University just opened in Tomsk, Count Demidoff contributed £9000, M. Cybulsky £7500, and the State the balance, £22,000. M. Sibiriakoff has made a donation of £8500 for scientific Scholarships.

THE Hon. A. C. Houen, a Norwegian resident at Rome, has presented the Christiania University with £6500 for the purpose of founding scientific Scholarships. He recently gave the same institution £10,000 for a like object.

AT a recent meeting of the Geographical Society of Stockholm, Dr. F. Svenonius read a paper on the origin and present state of the glaciers of Europe, dividing them into Alpine, Greenland, and Scandinavian. Referring to the latter, Dr. Svenonius stated that the glaciers of Sweden, to which he had devoted years of study, were far more important than was generally imagined. They could be divided into some twenty different groups, all being situated between 67° and 68½° lat. N., *i.e.* between the sources of the Pile River and Lake Torne. They number upwards of one hundred, and cover a total area of at least 400 square kilometres. The largest is the Sorjik group, the area of which is between 65 and 75 square kilometres.

THE great "Bibliography of Meteorology," at which Mr. C. J. Sawyer, of the United States Signal Service, has been working for some years, is now completed. It comes down to the year 1881, inclusive; and Mr. Sawyer estimates that it contains 50,000 independent titles. General Greely, the Chief Signal Officer, is anxious that the work should be printed; and in his last Annual Report he pointed out that, if this were done, future international co-operation would probably secure, by a system of rotation, from the various European Governments, the publication of a series of supplements which would keep the world abreast of the steadily-increasing volume of meteorological publications.

THE Administration Report of the Meteorological Reporter to the Government of Bengal for the year 1887–88 states that it has been decided to submit, for two years only, brief accounts of the principal points, while every third year a detailed Report is to be prepared. The present Report is the first of the triennial series. The most important changes during the year have been in the storm-signal service. Until recently, regular storm-signals were not allowed by the port authorities to be displayed in Calcutta, so that ships on several occasions left their safe anchorage in the port, and were proceeding down the river, before they became aware of the display of storm-signals. This condition has, however, been completely changed during the year 1887–88, and signals are now shown, by orders of the Bengal Reporter, in Calcutta, and have been extended to all the ports from the south of Burmah down to the extreme south of the Madras Presidency, or, roughly speaking, he has to warn a coast-line of about 2400 miles in length. His work and responsibility have therefore been very decidedly increased. The observations for the weather service are now taken at 8 a.m. instead of 10 a.m. The advantage of this change, for the issue of storm-warnings in useful time, is obvious.

THE Pilot Chart of the North Atlantic Ocean for September shows that the weather during August was generally fine over

that ocean. Gales of varying force, however, occurred about once a week over the steam-ship routes. On the 13th and 14th a depression moved along the coast of New England, and reached Newfoundland on the 15th; from this position it moved to the eastward, and appears to have reached this country. No other storm crossed the ocean entirely. Less fog was encountered than is usual during August, and with the exception of a few bergs in the Straits of Belleisle no ice was reported during the month.

M. G. ROLLIN, of the French Meteorological Office, has published in the *Annales* of that institution a valuable article entitled "Remarks on Synoptic Charts." He has carefully examined day by day the movements of the atmosphere, with the view of determining the possibility of predicting the arrival of storms coming from the Atlantic. His experience of the American telegrams coincides with that arrived at in this country, that they cannot at present be turned to practical use in weather prediction. But he has made a serious attempt to render them useful in the future, by the establishment of certain types which connect the weather of the Atlantic with that of the adjacent continents, and he finds that many conditions, without being actually identical, are sufficiently alike to be classified together. His concluding remarks, however, show that much further investigation is necessary before any definite rules can be laid down, and that the atmospheric changes are often so rapid that the difficulties of weather prediction on the exposed coasts of Europe are likely to remain very great for a long time to come.

A BEAUTIFUL crystalline substance of much theoretic interest was exhibited at the recent Bath meeting by its discoverer, Prof. Emerson Reynolds, F.R.S., of Dublin University. Its mode of formation and analysis prove that it is $Si(NHC_6H_5)_4$, or silicotetraphenylamide. It is the first well-defined compound in which silicon is exclusively united with the nitrogen of amidic groups, and is formed by the action of excess of phenylamine on silicon tetrabromide. The new compound crystallizes from carbon disulphide in fine transparent, colourless prisms, which melt sharply at 132°. When heated *in vacuo*, aniline distils over, and a residue is obtained which appears to be the silicon analogue of carbodiphenylimide. Considering the important part which silicon plays in Nature, and its close resemblance to carbon—which affords a large number of important nitrogen compounds—it is surprising that little is yet known of the relations of silicon and nitrogen. The investigation of the new substance is likely to throw much light on this general question.

AT the same meeting Prof. Emerson Reynolds also exhibited a number of new silicon compounds of a different type from that above noticed. They were obtained by the action of silicon tetrabromide on the primary thiocarbamide and some of its derivatives. The products are addition compounds: that obtained with the primary thiocarbamide has the formula $(H_4N_2CS)_8SiBr_4$, and analogous compounds were formed with allyl, phenyl, and diphenyl-thiocarbamides. The allyl product is a colourless and very viscous liquid, the others are vitreous solids at ordinary temperature. When the primary thiocarbamide compound is dissolved by ethylic alcohol, it is decomposed, and affords tetra- and tri-thiocarbamide derivatives free from silicon. The first of these products is a fine crystalline substance, whose formula is $(H_5N_2CS)_4NBr$; the second is a sulphinic compound, $(H_5N_2CS)_3Br . C_2H_5Br$. Prof. Reynolds succeeded in effecting the synthesis of the first compound by the direct union of thiocarbamide with ammonium bromide, and subsequently produced a series of similar bodies by substituting for ammonium bromide the bromides, iodides, and chlorides of ammonium bases. Although the derivatives of thiocarbamide are very numerous, only those were known which result from one or two molecules of the amide; but the existence of the new compounds exhibited by Prof. E. Reynolds proves that thiocarbamide can afford much more highly-condensed products.

AN important quantitative reaction between iodine and arseniuretted hydrogen has recently been investigated by Dr. Otto Brunn. During a series of attempts to completely eliminate arseniuretted hydrogen from sulphuretted hydrogen prepared from materials containing arsenic, it was found that this could be completely effected by passing the mixture over a layer of iodine. The mixed gases were first dried by passage through a calcium chloride tube, and were then led through a tube 12 mm. wide, containing the layer of powdered iodine; a plug of glass wool moistened with potassium iodide to remove vapour of iodine was placed at the end of the layer, and attached to the extremity of the tube were a couple of flasks containing lead acetate solution to absorb the sulphuretted hydrogen. On removing the iodine tube and heating the issuing gas in the usual drawn out form of hard glass tube, a fine mirror of metallic arsenic was deposited, but after insertion of the iodine tube not a trace of deposit was obtained, while a yellow coating of iodide of arsenic was formed upon the surface of the iodine. This led Dr. Brunn to experimentally determine whether the reaction was quantitative or not. Equal volumes of a mixture of hydrogen and arseniuretted hydrogen were passed in two successive experiments through a solution of silver nitrate in the one case, and over a layer of iodine 25 cm. long in the other. As is well known, silver nitrate is quantitatively reduced by the hydride of arsenic to metallic silver, the arsenic being oxidized to arsenious acid. It was found that the amount of arsenic absorbed by the iodine was exactly equal to that absorbed by the silver nitrate, and hence the iodine reaction is happily found to be also a quantitative one. Chemists have therefore a ready means of freeing both hydrogen and sulphuretted hydrogen from the last traces of this most objectionable hydride of arsenic. It was finally shown that hydride of antimony behaves in a precisely similar manner with iodine.

THE Trustees of the Australian Museum have issued their Report for 1887. The total number of visitors was 122,799, as against 127,231 in 1886. This Museum is open on Sundays from 2 o'clock to 5, and the privilege seems to be much appreciated. The average daily attendance throughout the year was 330 on week-days and 709 on Sundays. The collections of the Museum are being steadily increased, mainly by purchases, exchanges, and donations, but also by collecting and dredging expeditions sent out by the authorities of the institution. An expedition, under the charge of Messrs. Cairn and Grant, to the Bellenden Ker Ranges, in Northern Queensland, resulted in obtaining for the Museum about sixty-eight species (198 specimens) of birds, and eleven species (thirty-five specimens) of mammals, seven of which are new to the Museum, and three are new to science; besides a number of insects and other Invertebrates. The Trustees were enabled also during the year to send an Expedition to Lord Howe Island, in company with the Visiting Magistrate, Mr. H. T. Wilkinson. The Ethnological Hall referred to in last year's Report has been fitted up with cases, and the valuable ethnological collections, mostly acquired during recent years, are arranged there. The Trustees anticipate that this will prove to be "not the least interesting portion of the Museum."

AN interesting "Hand-book of Sydney" has been published for the use of the members of the Australasian Association for the Advancement of Science. The editor is Mr. W. M. Hamlet, Government Analyst, Sydney. His object is to give an epitome of the history, meteorology, geology, flora, and fauna of Sydney and the surrounding neighbourhood, together with a brief account of the commerce and industries which have grown up in the mother country of Australia during the first half-century.

THE Royal Society of Canada has issued its Proceedings and Transactions during the year 1887. This is the fifth volume of the series. Among the papers (some of which are in French) we may note the following: the Eskimo, by Franz Boas; notes and observations on the Kwakiool people of the northern part of Vancouver Island, and adjacent coasts, made during the summer of 1885, with a vocabulary of about seven hundred words, by George M. Dawson; on the Indians and Eskimos of the Ungava District, Labrador, by Lucien M. Turner; on a specimen of Canadian native platinum from British Columbia, by G. Christian Hoffmann; microscopic petrography of the drift of Central Ontario, by A. P. Coleman; Michel Sarrazin: matériaux pour servir à l'histoire de la science en Canada, by the Abbé Laflamme; a review of Canadian botany from the first settlement of New France to the nineteenth century, by D. P. Penhallow; illustrations of the fauna of the St. John group, by G. F. Matthew; squirrels, their habits and intelligence, with especial reference to feigning, by T. Wesley Mills.

THE first volume of the "Geological Record," for 1880-84 (inclusive), has just been published. The second volume is partly in type, and will be ready by the end of the year. The editors are Mr. W. Topley and Mr. C. Davies Sherborn. Three alterations have been made in this issue of the "Record." Titles only are given; physical geology is all included under one heading, instead of three as heretofore; supplements are abolished, titles omitted from previous years appearing in the main text.

ACCORDING to the Report of the Committee of Council on Education (England and Wales) for the past year, the class subjects under the head of "Elementary Science" have practically not been taught in the elementary schools throughout the country. Only thirty-nine schools have taken up any of these subjects, while geography, for instance, has been taught in 12,035 schools. With regard to the training colleges for teachers it has of late years been arranged that success in the examinations in science held by the Science and Art Department should be reckoned in fixing the students' places in the class list of candidates for certificates as teachers of public schools. It is curious that in the training colleges in Wales—Bangor, Carmarthen, and Carnarvon—not a single student presented himself in mathematics, theoretical mechanics, animal physiology, or inorganic chemistry; and out of 713 male students who passed the examinations in science under the Science and Art Department before entering training colleges in the country only seven passed in applied mechanics, nine in organic chemistry, and six in botany. Amongst the female students who passed the Science and Art Department, animal physiology and physiography were the favourite subjects, while not one passed in applied mechanics, only one in theoretical mechanics, and three in organic chemistry.

WE have received a copy of "Rural School Education in Agriculture (Scotland)," the opening lecture delivered to an agricultural class of rural teachers in the University of Edinburgh by Prof. Robert Wallace. At the outset he gives a short history of agricultural education in the University of Edinburgh (the Chair was founded in 1790), and comments on the fact that the students attending his classes are rural schoolmasters from every county in Scotland. Last year a Government grant of £300 to the University enabled the Senate to arrange special classes for his hearers. The students, he says, are not intended to be farmers. They are to be, so to speak, literary experts on agricultural matters, who are to direct the minds of lads in rural districts into proper channels, and to stir up amongst them an intelligent curiosity as to the animal and plant life around them. A suggestion made by Prof. Wallace as to the formation of libraries for the help of the rural teachers is worthy of attention. Each of these libraries should have a cyclopædia of agriculture, and one guinea a year should be expended on each to provide some leading agricultural periodical. This is all that would be absolutely necessary. He also advocates the changing of the text-books at present in use in agricultural classes in Scotland.

THE additions to the Zoological Society's Gardens during the past week include a Patas Monkey (*Cercopithecus patas* ♀) from West Africa, presented by Master Lewis Levy; a Drill Baboon (*Cynocephalus leucophæus* ♀) from West Africa, presented by the Rev. G. H. Richardson; a Rhesus Monkey (*Macacus rhesus* ♀) from India, presented by Miss Jessie Bone; a Common Marmoset (*Hapale jacchus*) from Brazil, presented by Miss Maud Bryden; a Ring-tailed Coati (*Nasua rufa* ♂) from Demerara, presented by Mr. Robert Sentonally; two Grey Ichneumons (*Herpestes griseus* ♂ ♀) from India, presented respectively by Mr. A. Cresser and Miss Alice Rutherford; two West African Love Birds (*Agapornis pullaria*) from West Africa, presented by Miss Ethel Levy; a Salt-water Terrapin (*Clemmys terrapin*) from North America, presented by Mr. Nicholas Fenwick Hele; four Blue-bearded Jays (*Cyanocorax cyanopogon*) from Para, a Violaceous Night Heron (*Nycticorax violaceus*) from South America, purchased; a Laughing Kingfisher (*Dacelo gigantea*) from Australia, deposited.

## *OUR ASTRONOMICAL COLUMN.*

THE LIGHT-CURVE OF U OPHIUCHI.—Mr. S. C. Chandler investigated the light-curve of this most interesting variable about a year ago (NATURE, vol. xxxvii. p. 36), and found evidence of a slight shortening of the period. Mr. Chandler's light-curve also showed an irregularity in the increase of light after minimum, similar to that which Schönfeld had already exhibited in the light-curves of Algol and S Cancri—a diminution, that is, in the speed of recovery almost amounting to a short halt. It is evident that it is of great importance to decide whether this irregularity is due merely to some personality of the observer, or is truly characteristic of the star's variation, for in the latter case it would be difficult to reconcile it with the view now generally held that the variability of stars of the Algol type is due to the transit of a dark satellite. Mr. Sawyer has recently published (*Gould's Astronomical Journal*, No. 177) the light-curve from his own observations, which are 527 in number, made on 57 nights, and involve 1135 comparisons. Mr. Sawyer's curve shows an irregularity similar to but slighter than that of Mr. Chandler's, but the retardation takes place sooner after the minimum, and the mean of the two curves gives an almost perfectly symmetrical curve for both decrease and recovery. It would seem likely, therefore, that for this star at least this curious irregularity is a purely subjective one, and the regularity of the mean curve would seem to afford confirmation to the satellite theory.

COMETS BROOKS AND FAYE.—The following ephemerides are in continuation of those given in NATURE, vol. xxxviii. p. 503, and p. 528:—

| 1888. | Comet 1888 *c* (Brooks). R.A. h. m. s. | Decl. ° ′ | Comet 1888 *d* (Faye). R.A. h. m. s. | Decl. ° ′ |
|---|---|---|---|---|
| Oct. 15 | 16 14 43 | 5 57·4 N. | 7 33 20 | 11 11 N. |
| 17 | 16 19 50 | 4 57·6 | 7 36 29 | 10 47 |
| 19 | 16 24 49 | 4 0·1 | 7 39 32 | 10 23 |
| 21 | 16 29 38 | 3 4·8 | 7 42 28 | 9 59 |
| 23 | 16 34 22 | 2 11·9 | 7 45 17 | 9 35 |
| 25 | 16 38 58 | 1 21·8 | 7 47 59 | 9 11 |
| 27 | 16 43 28 | 0 32·8 N. | 7 50 34 | 8 47 N. |

COMET 1888 *e* (BARNARD).—Mr. W. R. Brooks discovered this comet independently on the following morning to that on which Mr. Barnard discovered it at Mount Hamilton.

*Ephemeris for Berlin Midnight* (*continued from* NATURE, vol. xxxviii. p. 528).

| 1888. | R.A. h. m. s. | Decl. ° ′ | Log *r*. | Log Δ. | Brightness. |
|---|---|---|---|---|---|
| Oct. 12 | 6 23 14 | 6 59·5 N. | 0·3523 | 0·2550 | 3·51 |
| 14 | 6 19 19 | 6 39·7 | | | |
| 16 | 6 14 58 | 6 18·6 | 0·3466 | 0·2265 | 4·10 |
| 18 | 6 10 12 | 5 56·2 | | | |
| 20 | 6 4 57 | 5 32·4 | 0·3410 | 0·1972 | 4·80 |
| 22 | 5 59 12 | 5 7·1 | | | |
| 24 | 5 52 55 | 4 40·3 N. | 0·3354 | 0·1672 | 5·60 |

The brightness on September 2 has been taken as unity.

## ASTRONOMICAL PHENOMENA FOR THE WEEK 1888 OCTOBER 14–20.

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

*At Greenwich on October 14*

Sun rises, 6h. 25m.; souths, 11h. 45m. 54·5s.; sets, 17h. 7m.: right asc. on meridian, 13h. 19·7m.; decl. 8° 25′ S. Sidereal Time at Sunset, 18h. 42m.

Moon (Full on October 19, 21h.) rises, 15h. 33m.; souths, 20h. 13m.; sets, 1h. 1m.*: right asc. on meridian, 21h. 48·6m.; decl. 15° 42′ S.

| Planet. | Rises. | Souths. | Sets. | Right asc. and declination on meridian. | |
|---|---|---|---|---|---|
| | h. m. | h. m. | h. m. | h. m. | ° ′ |
| Mercury.. | 8 57 | 13 15 | 17 33 | 19 49·1 | 19 37 S. |
| Venus..... | 8 49 | 13 23 | 17 57 | 14 57·1 | 17 4 S. |
| Mars...... | 12 15 | 15 57 | 19 39 | 17 31·6 | 24 53 S. |
| Jupiter.... | 10 29 | 14 40 | 18 51 | 16 14·7 | 20 43 S. |
| Saturn.... | 0 22 | 7 51 | 15 20 | 9 24·2 | 16 7 N. |
| Uranus ... | 6 2 | 11 33 | 17 4 | 13 6·9 | 6 28 S. |
| Neptune.. | 18 42* | 2 28 | 10 14 | 4 0·7 | 18 53 N. |

* Indicates that the rising is that of the preceding evening and the setting that of the following morning.

*Occultations of Stars by the Moon* (visible at Greenwich).

| Oct. | Star. | Mag. | Disap. | Reap. | Corresponding angles from vertex to right for inverted image. | |
|---|---|---|---|---|---|---|
| | | | h. m. | h. m. | ° | ° |
| 16 | 74 Aquarii | 6 | 0 57 | 1 8 | 66 | 49 |
| 16 | B.A.C. 8214 | 6½ | 21 21 | — | 203 | — |
| 20 | μ Ceti | 4 | 23 39 | 0 41† | 63 | 338 |

† Occurs on the following morning.

| Oct. | h. | |
|---|---|---|
| 20 | 21 | Mercury stationary. |

*Variable Stars.*

| Star. | R.A. | Decl. | | | |
|---|---|---|---|---|---|
| | h. m. | ° ′ | | | h. m. |
| U Cephei | 0 52·4 | 81 16 N. | Oct. | 16, | 3 11 *m* |
| Mira Ceti | 2 13·7 | 3 29 S. | ,, | 15, | *M* |
| T Monocerotis | 6 19·2 | 7 9 N. | ,, | 18, | 3 0 *M* |
| U Geminorum | 7 48·5 | 22 18 N. | ,, | 15, | *M* |
| R Camelopardalis. | 14 26·1 | 84 20 N. | ,, | 17, | *M* |
| T Ophiuchi | 16 27·3 | 15 54 S. | ,, | 18, | *M* |
| U Ophiuchi | 17 10·9 | 1 20 N. | ,, | 16, | 19 46 *m* |
| Z Sagittarii | 18 14·8 | 18 55 S. | ,, | 17, | 19 0 *M* |
| β Lyræ | 18 46·0 | 33 14 N. | ,, | 19, | 22 0 *M* |
| R Lyræ | 18 51·9 | 43 48 N. | ,, | 18, | *M* |
| η Aquilæ | 19 46·8 | 0 43 N. | ,, | 20, | 1 0 *M* |
| T Vulpeculæ | 20 46·7 | 27 50 N. | ,, | 20, | 23 0 *M* |
| Y Cygni | 20 47·6 | 34 14 N. | ,, | 14, | 3 0 *m* |
| | | | ,, | 17, | 3 0 *m* |
| | | | ,, | 20, | 3 0 *m* |
| δ Cephei | 22 25·0 | 57 51 N. | ,, | 16, | 23 0 *m* |

*M* signifies maximum; *m* minimum.

*Meteor-Showers.*

| | R.A. | Decl. | |
|---|---|---|---|
| Near ξ′ Ceti | 30° | 9° N. | Slow; trained. |
| ,, ε Arietis | 42 | 20 N. | Swift. |
| ,, ν Orionis | 90 | 15 N. | The *Orionids.* |
| ,, ζ Geminorum | 105 | 22 N. | Swift; streaks. |

## GEOGRAPHICAL NOTES.

WE notice in the last number of the *Izvestia* of the East Siberian Geographical Society (vol. xix. 1), a most interesting note, by L. A. Jaczewski, on the geological results of the last Sayan expedition. The immense border-ridge of the great plateau of East Asia, which stretches from the sources of the Iya to Lake Baikal, was very little known. Many explorers have visited the valleys of the Irkut and Oka which flow at its northern base, but very few have crossed it, and if they crossed the huge ridge, it was mostly to the north of Lake Kosogol, where a broad passage is opened from the lowlands to the high plateau. The Expedition of MM. Prein and Jaczews crossed it at three different places, and thus obtained an insight into its geological structure. As to its age, it appears that limestones, most probably Silurian, lie almost undisturbed at its northern base, so that the hypothesis as to the great plateau having been a continent since the Laurentian or Huronian epochs is thus confirmed. We notice also that, besides Munku Sardyk, 3500 metres high, there are in the Sayan at least three or four summits of nearly the same height; and that, viewed from the south on the banks of the Kirlygoi stream, it appears as a massive wall, 700 metres high, having a direction from the north-west to the south-east. As to the complex ramifications of the Sayan, they are chiefly due to a most extensive action of atmospheric agencies, as was foreseen by Tchersky. Most interesting observations were made as to the formerly quite unknown glaciers of the northern slope, where they have the shape of narrow glaciers descending down a very steep slope and taking their origin amidst wide snow-fields. Their lower extremities reach a lower level than on the southern slopes. As to the former extension of glaciers, which was maintained by Kropotkin, but doubted on account of prevailing theoretical conceptions as to the non-glaciation of Siberia, M. Jaczewski found plenty of striæ and striated boulders which made him consider that glaciers formerly extended to a level of 1500 metres on the northern slope, and 1700 metres on the southern slope turned towards the plateau.

THE French Maritime Survey is sending a special mission to map the coasts of Madagascar. The officers will leave Paris in a few days, and are busy at the St. Maur Magnetic Observatory regulating their instruments for this purpose.

## ELECTRICAL NOTES.

PROF. FITZGERALD (B. A. Address, Section A), in drawing attention to Hertz's experiments, has done the greatest possible service to electrical science. Hertz not only proves the existence of the ether, but the fact that an electric field is due to the oscillatory motions of the ether. Everyone who has the means will probably be repeating these experiments. The *Electrician* is publishing a capital *résumé* of Hertz's work by Mr. De Tunzelmann. Prof. Fitzgerald himself had predicted this result at Southport in 1882, and Prof. Oliver Lodge has actually measured these wave-lengths—the shortest ether wave measured being 3 yards—by extremely simple and beautiful experiments.

ACHESON (NATURE, July 26, p. 305) is pursuing in Pittsburg his inquiry into the influence of the disruptive discharges of powerful alternating currents. He confirms his formula, $\frac{E^3 \times K}{a} = d$, $d$ being the sparking distance in inches and $a$ a constant, and finds for

| Dielectric. | Sparks between | $a$. |
|---|---|---|
| Air | points | 135 |
| Air | points and wire | 263 |
| Paraffin and cotton | ,, | 5822 |
| Ozite and cotton | ,, | 7759 |

Ozite is a residuum of petroleum.

LENARD and Howard (*Electrotechnik Zeitschrift*, July 1888), have succeeded in making flat spirals of pure bismuth which, in the magnetic field, vary in resistance from 10 to 20 ohms, according to the strength of the field, and form a good practical mode of roughly measuring its intensity as suggested by Leduc.

DR. BORGMAN, of St. Petersburg (*Phil. Mag.*, September 1888), has been experimenting on the transmission of electric currents through air when flames or points are used as electrodes. Some years ago, Prof. Hughes showed many of his friends similar experiments with telephones, but for some reason or other he has never published the results. The experiments were extremely interesting, as indeed are those of Borgman, who finds a difference in the surface resistance of the cathode and anode flames. He attributes much to the influence of light as studied by Hertz, Hallwachs, Wiedemann and Ebert, and Arrhenius. These results have a very important bearing on the new views of electrical action that are following from the inquiries of Fitzgerald, Hertz, Lodge, and others.

AN extremely suggestive and very original paper was read at the British Association by Prof. Hicks, "On a Vortex Analogue of Static Electricity." Attractions, repulsions, lines of force, charge, positive and negative electrification, induction,

strains of dielectrics—all the main phenomena of static electricity admit of explanation on the basis of hollow vortices in the ether. Moreover, the theory is applicable to chemical valency and to Faraday's law of electrolysis. It places Faraday's ideal lines of force on a basis of reality, and it adds one more nail to the coffin of the material theory of electricity which it is to be hoped has now been safely buried.

DURING a thunderstorm which lately burst over Barcelona, the captive balloon in the Exhibition was struck by a lightning-flash and destroyed. The connecting-rope was probably of wire.

THE lightning-conductor discussion at the Bath meeting of the British Association has raised the question of the oscillatory character of the Leyden jar discharge. This was suggested by Helmholtz, in 1852, as an explanation of the fact observed by Faraday, that when electrolysis of water took place through a Leyden jar discharge passing through it, the gases at each electrode were mixed H and O. It was proved by Thomson, in 1853, that if self-induction existed in the discharging circuit it must occur, and the oscillations were actually observed by Feddersen. The fact that needles and iron bars are magnetized militates rather against the theory, but Prof. Ewing (*Electrician*, October 5, p. 712) suggests that oscillations in which the period lengthens while their amplitude decays would account for magnetization in layers.

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## *MOLECULAR PHYSICS: AN ATTEMPT AT A COMPREHENSIVE DYNAMICAL TREATMENT OF PHYSICAL AND CHEMICAL FORCES.*[1]

### III.

### PART II.—ELECTRICITY AND MAGNETISM.

#### § 12. *Electrostatic Attraction.*

THOMSON'S investigations, considered in § 1 (August 23, p. 404), rest on the assumption that the diameter of a molecule or atom is indefinitely small in comparison with the wave-length of the light, and therefore the conclusions do not hold good for light-vibrations of such small wave-length as to be comparable with the molecular diameters. The consideration of vibrations of this kind shows that they give rise to what are called electrical phenomena.

These vibrations, like the former, will affect the internal energy of the molecules, and the molecules will also have critical periods with respect to them. But instead of assuming, as before, that within a finite but very short interval, only one wave impinges upon a molecule, it must now be assumed that an indefinitely large number of waves impinge upon the molecule at the same time, and that the effect of these waves is of a constant character. Suppose a sphere of a diameter differing only by an indefinitely small amount from that of a molecule, to be separated from the ether, and let vibrations of short wave-length impinge upon it from a fixed point, P. The first step will be to determine the energy, due to these vibrations, of the ether within the sphere.

Let $r_0$ be the least and $r_1$ the greatest distance of P from the spherical surface. The energy will be inversely proportional to the square of the distance, so that, where $\kappa$ is a constant, the energy of the vibrating ether within the sphere will be—

$$\int_{r_0}^{r_1} \frac{\kappa dr}{r^2} = \kappa\left(\frac{1}{r_0} - \frac{1}{r_1}\right) = \frac{\kappa\delta}{r^2},$$

where $\delta = r_1 - r_0$, and $r$ lies between $r_0$ and $r_1$.

Now consider a finite space bounded by spherical surfaces of radii $R_0$ and $R$, having their common centre at P, and by a cone with its vertex at P, and suppose it to be filled with spheres of diameters indefinitely near to those of molecules; then a finite number of concentric spherical surfaces may be inserted between the two bounding spheres, at distances equal to the diameter of a molecule. The number of small spheres between any pair of these spherical surfaces will be proportional to the spherical surface included within the cone, so that, if $d\sigma^i$ is the element of surface of the sphere of radius $R_i$, the total energy of the ether within the space considered will be proportional to—

$$\frac{\delta}{R_0^2}\int d\sigma_0 + \frac{\delta}{R_1^2}\int d\sigma_1 + \ . \ . \ . \ .$$

If, however, we assume that the small spheres are not sufficiently numerous to completely fill the space, but that they may all be arranged along a circular arc of radius R, then $R_i^2$ in these denominators must be replaced by $R_i$, so that, writing $dR$ for $\delta$, we find for the total energy—

$$\sum \frac{\delta}{R_i}\int d\sigma_i = \int_{R_0}^{R} \frac{dR}{R}\int d\sigma = \iiint \frac{dx\,dy\,dz}{R},$$

where $dx\,dy\,dz$ represents an element of volume in the most general form. We therefore obtain the following important result :—

If a portion of space infinitely large in proportion to the diameter of a molecule contains a number of spheres of the size of a molecule, so sparsely scattered that they can all be arranged on a surface within the space, then the total energy of the ether within all these spheres will be the same as if the space were completely occupied by the spheres, and the energy of each element of space were inversely proportional to the first power of the distance of the element from the point P.

Now suppose these spheres to be replaced by molecules with a similar scattered distribution, then the vibrations corresponding to their critical periods will increase their energy, while vibrations of different period will traverse the space unaltered, and therefore the molecules may still be regarded as specially susceptible to certain vibrations of very short period, just as in the case of luminous vibrations. Let $KR^{-1}$ be the energy of the ether within the space occupied by the molecules, then the ponderable portions of the molecules will have their energy increased by an amount $\theta KR^{-1}$, where $\theta$ is a proper fraction—that is to say, a force varying inversely as the square of the distance will act on the ponderable molecules.

Now, it was shown in § 1 that for comparatively slow molecular motions the ether behaves like a perfect fluid, and therefore it follows from the principles of hydrodynamics that the molecules must move in the direction in which the energy of the surrounding ether diminishes most rapidly—that is, towards P; for the increase in the energy of a molecule as it approaches P must be accompanied by a decrease in the energy of the ether surrounding it.

It therefore follows that the vibrations of very short wave-length proceeding from P will have the same effect as if P had a charge of electricity, which suggests that electrostatic phenomena may be due simply to these vibrations in the ether, and it will be found that further investigation confirms this conclusion. For the sake of brevity, the internal energy of a molecule due to vibrations of the short wave-length here considered will henceforth be called electrical energy, and a molecule will be said to be electrically excited when its electrical energy differs from zero. The demonstration given in § 5 (p. 407), that there is a maximum value for the possible internal energy of a molecule, will apply also to the present case, so that there will be a maximum possible value of the electrical energy of a molecule, depending upon the values of the constants which determine its internal constitution. This result leads to the following proposition :—

Two electrically excited particles will attract each other when the electrical energy of either one of them is, under the existing circumstances, susceptible of further increase. In the opposite case there will be repulsion.[1]

The truth of the latter portion of the preceding proposition is easily seen, for if two equally excited particles, or two excited to the maximum amount, were to approach each other, the energy of the intervening ether would increase in the direction of motion, for the ether at a point in the neighbourhood of one of the particles would receive an increase of energy from the approach of the other, while there could be no absorption of energy by the molecule. This would, however, be in contradiction with the law of hydrodynamics according to which the motion takes place in the direction of decreasing energy.[2]

[1] A Paper read before the Physico-Economic Society of Königsberg, by Prof. F. Lindemann, on April 5, 1888. Continued from p. 461.

[1] The action of electrified glass and sealing-wax on each other and on pith-balls is easily explained from this. The difference between positive and negative electricity being merely relative, appears, too, to remove a good many difficulties in the explanation of electrostatic phenomena.

[2] We therefore assume the truth of Maxwell's theory that light-vibrations exert a pressure in the direction of propagation ("Electricity and Magnetism," § 792); this will only be modified when the vibrations are absorbed by the ponderable molecules.

To determine exactly the conditions for attraction and repulsion respectively, let M be the electrical energy, at unit distance, of a vibration proceeding from P, then the energy at the distance R is $MR^{-1}$, as far as its effect on a molecule is concerned. Suppose a portion, $\epsilon MR^{-1}$, of this to be absorbed where $\epsilon$ is a proper fraction, then the repulsive force will be proportional to the negative differential coefficients of $(1-\epsilon)MR^{-1}$, and there will be at the same time an attractive force proportional to the differential coefficient of $\epsilon MR^{-1}$. The total repulsive force will therefore be proportional to $(1-2\epsilon)MR^{-2}$; its maximum value will be attained for $\epsilon = 0$; it will be zero for $\epsilon = \frac{1}{2}$: it will be attractive for $\epsilon > \frac{1}{2}$, and the attractive force will reach its maximum value for $\epsilon = 1$—that is to say, when the whole of the energy is absorbed. This may take place when the two attracting or repelling particles are of the same substance. The expressions for these forces contain, in addition to R, a factor M depending only on the attracting particle, and a factor $1 - 2\epsilon$ depending only on the attracted particle. In the same way the second particle will exert upon the first P a force proportional to $(1 - 2\eta)NR^{-2}$, where $\eta$ depends only on the first particle, and N only on the second. The electrostatic potential of the mutual action will therefore be—

$$-\frac{(1-2\epsilon)(1-2\eta)MN}{R} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (28)$$

M and N measure the electricity radiated from the two particles respectively—that is to say, the excess of the internal electrical excitation of the two particles over that of the surrounding ether. This excess may be negative, and therefore two unelectrified particles may repel each other (when $\epsilon = 0$, $\eta = 0$) provided the surrounding medium is excited. The next step would be to determine the further motion of an attracted or repelled electrified particle, but since electricity in motion behaves quite differently from electricity at rest, as will be shown to follow from the author's theory, the consideration of this problem must be postponed, but it may be noted here that an attracted particle can only continue to approach the attracting particle so long as its maximum energy has not been attained. They may therefore either continue to approach until they come into contact, or may cease to approach at a certain critical distance. The latter possibility does not seem allowable according to experience, and in fact is found to be excluded when the motion is more fully considered, and the author merely mentions it in this place to call attention to its relation to the objections brought by von Helmholtz against Weber's theory.

Attempts have already been made to explain Newtonian gravitation from electrostatic actions.[1] The attempt to explain gravitation in this manner derives additional interest from the author's theory of electrostatic action, according to which the earth receives from the sun's rays, not only heat and light, but also electrical energy.

The theory of planetary motion should be capable of being derived from the laws of electro-dynamics, and the author's theory may therefore possibly prove of great value for the explanation of the phenomena of terrestrial magnetism, of meteorology, and may perhaps also throw some light upon the nature of comets.

### § 13. *Electro-dynamic Potential of Two Currents.*

Electrostatic action may be compared, according to the author's theory, with heat radiation, since both series of phenomena are due to the transference of energy from the ether to ponderable molecules. Similarly, heat conduction may be compared with electrical conduction. A body will be defined as a conductor when its molecules, in virtue of specially favourable values of its critical periods and other constants, are so sensitive to electrical energy as to easily absorb the maximum amount of internal energy, after which the centres of gravity of the molecule will begin to execute exceedingly small vibrations, which will be transmitted from molecule to molecule, accompanied by an absorption of electrical energy by each molecule, in exactly the same way that the molecules become luminous by the absorption of energy in the form of heat vibrations. Conduction, then, will take place by electrostatic radiation from molecule to molecule.[1] Those substances, on the other hand, in which the molecules absorb with difficulty the maximum amount of electrical energy, or in which internal electrical vibrations are only excited with difficulty, will be non-conductors.

The energy of an electrical vibration is inversely proportional to the square of the period of vibration, and therefore to the square of the wave-length, $\lambda$. A very good conductor (and these alone are considered in electro-dynamics) must have a very large number of critical wave-lengths lying so close together that their sum may be represented by a definite integral. Let $\lambda_1$ be the smallest, and $\lambda_2$ the greatest, of the electrical wave-lengths to be considered in any given case, then the internal electrical energy of the molecule will be proportional to

$$\int_{\lambda_1}^{\lambda_2}\frac{d\lambda}{\lambda^2} = \frac{1}{\lambda_1} - \frac{1}{\lambda_2} = \frac{\lambda_2 - \lambda_1}{\lambda^{1^2}},$$

where $\lambda^1$ is a value of $\lambda$ lying between $\lambda_1$ and $\lambda_2$. Owing to the number of critical wave-lengths being necessarily very large, $\lambda_2 - \lambda_1$ will be a finite quantity in comparison with $\lambda^1$. We therefore arrive at the conclusion that the total internal electrical energy of a molecule of a good conductor is inversely proportional to a certain mean critical wave-length $\lambda^1$.

If we now make the assumption that the electrified particles are moving relatively to each other with a given velocity, their mutual electrostatic action will be modified in the same manner as if the wave-length of the electrical vibration proceeding from each of them were increased or diminished by an amount $\Delta\lambda$. Let $c$ be the velocity of light, and $\rho$ the relative velocity of the two electrified particles, in the direction of the line joining them, then we know that $\Delta\lambda = \lambda\rho/c$. Let $r$ be the initial distance between the particles, and $E/r\lambda = M/r$ the initial electrostatic potential of one due to the presence of the other, then during the motion it will be—

$$\frac{E}{r(\lambda + \Delta\lambda)} = \frac{E}{r\lambda\left(1 + \frac{\rho}{c}\right)} = \frac{M}{r}\left(1 - \frac{\rho}{c} + \frac{\rho^2}{c^2} - \ldots\ldots\right).$$

Let $ds$ be the element of length of the first conductor, and $ds'$ that of the second, and let $\theta$ and $\theta'$ be the angles which they make with the joining line, then—

$$\rho = \frac{ds}{dt}\cos\theta - \frac{ds'}{dt}\cos\theta' \quad . \quad . \quad . \quad . \quad . \quad . \quad (29)$$

To determine the mutual action of the two current elements, each element must be assumed to consist of a pair of molecules, one of which has transmitted electrical energy to the other without having itself received a fresh supply, an assumption in complete accordance with the representation of a molecule as consisting of a series of distinct shells, and which takes the place of the assumption usually made that at each moment the quantities of positive and negative electricity on every current-element are equal. The two original elements will repel each other if the internal energy is electrically excited to an equal extent, or to the maximum amount possible in each. In order to fix the ideas this may be assumed to be the case in what follows.

Let 1, 2, represent the two molecules of the element $ds$, and 1′, 2′, those of $ds'$, then the mutual potential of the two elements will be represented by the sum—

$$P_{22'} + P_{12'} + P_{1'2} + P_{11'};$$

where $P_{ik}$ represents the mutual potential of two molecules $i$ and $k$. The author takes the potential such that its positive differential coefficient in any direction is equal to the component of force in that direction, and therefore we have—

$$P_{22'} = -\frac{M}{r}\left(1 - \frac{\rho}{c} + \frac{\rho^2}{c^2} \ldots\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (30)$$

$$P_{12'} = \frac{M}{r\left(1 + \frac{ds}{dt}\frac{\cos\theta}{c}\right)} = \frac{M}{r}\left(1 - \frac{ds}{dt}\frac{\cos\theta}{c} + \left(\frac{ds}{dt}\frac{\cos\theta}{c}\right)^2 - \ldots\right) \ldots (31)$$

$$P_{1'2} = \frac{M}{r\left(1 - \frac{ds'}{dt}\frac{\cos\theta'}{c}\right)} = \frac{M}{r}\left(1 + \frac{ds'}{dt}\frac{\cos\theta'}{c} + \left(\frac{ds'}{dt}\frac{\cos\theta'}{c}\right)^2 + \ldots\right) \ldots (32)$$

$$P_{11'} = -\frac{M}{r} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (33)$$

[1] By Mossotti, for example, in 1836; see Zöllner's "Wissenschaftliche Abhandlungen," vol. ii. p. 417 (Leipzig, 1878). On p. 16 *et seq.*, various hypotheses regarding action at a distance are collected together, but the author states that he does not agree with Zöllner's criticisms on them. See also Maxwell's "Electricity and Magnetism," Articles 37, 59, *et seq.*, and 846 *et seq.*

[1] Kundt has recently shown that heat conduction is probably effected in a similar manner (*Sitzungsberichte der Berliner Akademie*, 1888, p. 271).

The constant M, according to (28), depends on the two current elements, and measures the electrical energy of the medium between them.

In (30) $\epsilon = 0, \eta = 0$; in (31) $\epsilon = 0, \eta = 1$; in (32) $\epsilon = 1, \eta = 0$; in (33) $\epsilon = 1, \eta = 1$.[1]

Substituting for $\rho$ its value from (29), and neglecting the second and higher powers, we find for the electro-dynamic potential of the two current elements—

$$dV = \frac{2M}{c^2} \cos\theta \cos\theta' \, ds ds' \quad . \quad . \quad . \quad . \quad . \quad (34)$$

which gives for the potential of two closed circuits—

$$V = \frac{2}{c^2} \int\int M \cos\theta \cos\theta' \, ds ds' \quad . \quad . \quad . \quad . \quad (35)$$

where M is an electrostatic constant and $c$ the velocity of light.

In the case of closed circuits we know that the value of V remains unchanged if $\cos\theta \cos\theta'$ is replaced by $\cos(ds, ds')$, and therefore we arrive at Neumann's expression for the mutual potential of two closed circuits, namely—

$$V = \frac{2}{c^2} \int\int M \cos(ds, ds') \, ds ds' \quad . \quad . \quad . \quad . \quad . \quad (36)$$

These expressions for V have been obtained by neglecting the second and higher powers of $\rho/c$, $1/c \cdot ds/dt$, and $1/c \cdot ds'/dt$; moreover, the dependence of the energy on the wave-length was only expressed in terms of a mean value, $\lambda'$; so that the expressions are only to be considered as approximately true. It is evident that they cannot hold good if either of the quantities $\rho$, $\frac{ds}{dt}$, or $\frac{ds'}{dt}$ become equal to or greater than the velocity of light—that is to say, both the relative and absolute velocities of the particles must be less than that of light; and it will be shown in what follows that this limitation is of the utmost importance.[2]

§ 14. *Weber's Fundamental Law.*

von Helmholtz has investigated the mutual potential of two current elements on the assumption that it is of the form—

$$\frac{M}{c^2}\left\{(1 + \kappa)\cos(ds, ds') + (1 - \kappa)\cos\theta\cos\theta'\right\} ds ds'.$$

Putting $\kappa = -1$, this expression agrees with Weber's law and also with (34), showing that the author's theory leads to Weber's law. In fact, putting $\theta = 0$, $\theta' = \pi$, and $ds = ds' = dr/2$, and taking the sum[3] of the electrostatic and electro-dynamic potentials, we arrive at Weber's expression for the potential of the two particles, namely—

$$-\frac{M}{r}\left\{1 - \frac{1}{2c^2}\left(\frac{dr}{dt}\right)^2\right\},$$

and the author's expression for $dV$ leads to Weber's expression for the repulsion between two particles, namely—

$$\frac{M}{r^2}\left\{1 - \frac{1}{2c^2}\left(\frac{dr}{dt}\right)^2 + \frac{r}{c^2}\frac{d^2r}{dt^2}\right\}.$$

von Helmholtz's objections against Weber's law must now be considered, and his own examples may be taken.[4]

[1] All the electric rays proceeding from 2 will not be absorbed by 1′ unless (§ 12) the two conductors are of the same material; if they are of different material, $\epsilon$ and $\eta$ can only approximately assume the value unity, and therefore the expression (35) will only give an approximate value of the mutual potential. From a physical point of view, it would perhaps be more reasonable to assume that the particles in the elements $ds$ and $ds'$ respectively, instead of being, one strongly electrified and one unelectrified, are distributed in an approximately regular manner throughout all the intermediate stages. In this case the sum of the four expressions (30)–(33) will have to be replaced by a double integral, of which this sum will be the mean value.

[2] These conditions are known experimentally to be fulfilled, for while the velocity of light is about 300,000 kilometres a second, that of electricity in wires is, according to Fizeau, Gounelle, Fröhlich, and W. Siemens, from 100,000 to 260,000 kilometres a second. See Sir W. Thomson, "Mathematical and Physical Papers," vol. ii. p. 131, and Wüllner's "Experimental Physik," vol. iv. p. 403, 4th edition. According to the author's theory, the propagation of electric waves *in vacuo* must take place with the velocity of light; but the theory would not be affected if the velocity in air were found to be different. See von Helmholtz, "Wissenschaftliche Abhandlungen," vol. ii. p. 629 *et seq.* In fact, Hertz has found this velocity to be distinctly greater than that of light (*Sitzungsberichte der Berliner Akademie*, February 1888). The increase may be due to the electrical excitation of the air particles, and their consequent repulsive action on one another. With respect to electro-dynamic determinations of the constant $c$, see Himstedt, *Wiedemann's Annalen*, vols. xxviii. and xxix.

[3] See Riemann, "Schwere, Electricität, und Magnetismus," §§ 96 and 97. It should be noted that Riemann uses $c$ to denote the velocity of light multiplied by $\sqrt{2}$. It may also be noted that the author uses $ds/dt$ and $ds'/dt$ to denote the velocity of propagation of an electrical disturbance, and not directly that of a molecule.

[4] "Wissenschaftliche Abhandlungen," vol. ii. p. 636 *et seq.* The two equations which follow may be interpreted as meaning that the quantity of electricity in motion depends on $r$, which is in agreement with § 12.

Suppose a ponderable electrified particle of mass $\mu$ to be repelled by a stationary quantity of electricity at the origin, in the direction of the joining line $r$. Let a force R of the ordinary kind act on the mass $\mu$ so as to diminish $r$, then the differential equation of motion of the electrified particle will be—

$$\mu\frac{d^2r}{dt^2} = \frac{M}{r^2}\left\{1 - \frac{1}{2c^2}\left(\frac{dr}{dt}\right)^2 + \frac{r}{c^2}\frac{d^2r}{dt^2}\right\} + R;$$

or, putting $M = \rho\mu c^2$—

$$\mu\left(1 - \frac{\rho}{r}\right)\frac{d^2r}{dt^2} = \frac{M}{r^2}\left\{1 - \frac{1}{2c^2}\left(\frac{dr}{dt}\right)^2\right\} + R.$$

Choosing the initial circumstances, so that $t = 0$, when the velocity and the work done by R are both zero, and supposing that $r$ then has the value $\mathfrak{r}$, the principle of conservation of energy gives—

$$\frac{1}{2}\mu\left(1 - \frac{\rho}{r}\right)\left(\frac{dr}{dt}\right)^2 = M\left(\frac{1}{\mathfrak{r}} - \frac{1}{r}\right) + \mathfrak{R},$$

where

$$\mathfrak{R} = \int_0^t R\frac{dr}{dt}dt.$$

If, now, $Rr^2 < -M$, von Helmholtz points out that the moving particle must always approach the stationary one; its velocity meanwhile increases without limit until, for a distance $r = \rho$ (the so-called critical distance, see § 12), it becomes infinite, so that a finite force can give an infinitely great velocity to a mass $\mu$ by a finite expenditure of work. This impossible result is not, however, a consequence of the author's theory, owing to the limitations stated at the end of § 13. For if the velocity $\frac{dr}{dt}$ increases without limit, it must exceed that of the velocity of light, and then Weber's law ceases to hold good.

It would be easy, by expanding the four previously-considered partial potential expressions, in terms of $c/\rho$, $c/ds/dt$, and $c/ds'/dt$, to obtain a law for the further motion; but there is no object in doing so, as it will be seen from what follows that this new law would again only hold up to a certain limit not far removed from the first.

In the first place, it is doubtful whether, when moving so rapidly, the ponderable molecules could traverse the ether without resistance. In the second place, the electrical energy transferred from the fixed origin to the moving particle has been assumed to be inversely proportional to the wave-length, and the latter has been regarded as varying gradually within the given limits. This was allowable for good conductors, since their molecules must be specially sensitive to electrical disturbance, and therefore have a very large number of very small critical periods. With the very great velocity assumed, the wave-lengths of the disturbances proceeding from the origin will be greatly shortened before acting on the mass $\mu$. It will follow, therefore, that only such vibrations will cause electrical excitation which already have so great a wave-length that they will really appear as light, or ultra-violet, vibrations, and not as electrical vibrations. Now, in the case of all known substances, these critical wave-lengths do not come together in great numbers, and therefore cannot be treated as forming a continuous series.

If such rays are emitted from the origin, they can only give rise to electrical excitation by separate impulses, and will therefore only cause a slight temporary variation in the acceleration of the particle $\mu$ due to the steady action of the force R.

We may therefore conclude that a particle easily susceptible of electric excitation will be electrified if it is made to approach a source of light with very great velocity, and this the more readily, the higher the refrangibility of the light from the source. The requisite velocity must exceed that of light by a definite amount.

The author is not aware that this conclusion has as yet been directly verified by any experimental evidence, unless Hertz's observations of the effect of light on the electric spark[1] may be explained in this way, but it is indirectly supported by the phenomena observed in Geissler tubes, as will be shown below. Consider, moreover, the motion of the particle $\mu$ away from the origin at an equally great velocity, then electrical waves proceeding from the origin will be lengthened, and act on the particle as light waves, causing it to glow. This electric glow will first appear of a blue colour, gradually passing through the various colours of the spectrum towards the red, as the velocity further

[1] *Sitzungsberichte der Berliner Akademie*, 1887, pp. 487 and 895.

increases, and of this electric glow many instances could be cited, both in Nature and in the laboratory.

Consider, in the first place, the glow surrounding a point from which an electric discharge is taking place. By means of the electrical repulsion, the density of the air immediately surrounding the point will be so far diminished that a single air-particle will be able to traverse a sensible distance with a very great velocity, and therefore give rise to the glow. Here it is not a question of particles becoming electrically excited by radiation from the point, but of those which are electrified by actual contact with it. As soon as they have lost some of their electrical energy they will again become sensitive to electrical radiation. There must therefore be a dark space immediately surrounding the point, and outside this an electric glow, which explains a well-known phenomenon always observed in the rarefied atmosphere of a Geissler tube. The stratification can also be explained very simply, for the glow causes a diminution in velocity, for when the electrical waves from the positive electrode give rise to luminous instead of electrical vibrations in the particles of gas, the repulsion will be diminished, and therefore the velocity will gradually become less than that of light, when the particle will again become sensitive to the electrical radiation. The velocity will therefore again increase until the glow appears again, thus giving rise to a stratified appearance. The velocity in the glowing layers will naturally be greatest in the neighbourhood of the positive electrode, and here, therefore, light will be given off of all the colours corresponding to the critical periods of the gas contained in the tube, which is in accordance with observation. According to the author's theory, the electrical excitation takes place by the transference of ponderable gas molecules from the positive to the negative electrode. After they have parted with their electrical energy to the latter, they will return in an unelectrified condition to the positive electrode to which they will be attracted, and at the same time repelled from the negative electrode. There will be no dark space surrounding the negative electrode, because the particles leaving it will have little or no electrification. The velocity of the returning molecules will increase as they approach the positive electrode, so that there can be no further transformation of electrical into luminous energy. In very high vacua the velocity of the returning particles may become great enough for electrical energy to be excited in them by the red glow of the positive pole, by which their velocity will be still further increased. The velocity of the returning particles will in this case ultimately become so much greater than that of the luminous molecules moving away from the positive electrode as to cause a sensible increase in the density of the gas surrounding it. The result of this will be to prevent the formation of the positive glow, and the whole tube will become filled by the negative glow. The density in the neighbourhood of the negative electrode will therefore be diminished, and the returning molecules will leave it with still greater velocity. If both electrodes are at one end of the tube, the molecules returning towards the positive electrode will be deflected by the layer of dense gas surrounding it, against the sides of the tube, giving rise to fluorescent phenomena, as explained in § 11 (September 6, p. 461). If the complicated phenomena which have recently been observed in Geissler tubes by Crookes and Hittorf can be thus simply explained, it will afford an important confirmation of the author's theory.

These considerations may be applied to the explanation of many cosmical phenomena, such as the aurora and the light of comets. It is quite possible that the particles of a comet's tail moving with great velocity towards the sun may become electrified by means of the sun's light.

The formulæ previously obtained are applicable to the determination of the motion of an electrified particle, in the case in which no proper luminous vibrations are given off from the origin, or where these may be neglected, for the equations (29) to (33) give in this case for $\frac{dr}{dt} = c$, $r = r_0$, $\mathfrak{R} = \mathfrak{R}_0$, and consequently—

$$\frac{\mu}{2}\left(1 - \frac{\rho}{r_0}\right)c^2 = \mathrm{M}\left(\frac{1}{r} - \frac{1}{r_0}\right) + \mathfrak{R}_0.$$

Also—

$$\frac{\mu}{2}\left[\left(\frac{dr}{dt}\right)^2 - c^2\right] = -\frac{2\mathrm{M}}{r} + \frac{\mathrm{M}}{r_0} + \frac{\mathrm{M}c}{r\frac{dr}{dt}} + \mathfrak{R} \equiv \mathfrak{R}_0.$$

And $dr/dt$ can hence only become infinite when the positive quantity $\mathfrak{R}$ becomes infinite, or $r = 0$. von Helmholtz's objections, therefore, do not apply to this equation.

§ 15.—*Electrical Excitation.*

The foregoing theory easily explains the different methods of electrical excitation.

(1) The friction of two bodies sets their molecules into vibration, which appears in the form of heat. The resulting impacts of neighbouring molecules will most readily excite internal vibrations of the critical periods, for which they are specially sensitive. If the molecules are exceptionally sensitive to vibrations of very short periods, they will be easily electrified, the process being exactly analogous to the production of luminous vibrations by heating gases, as described in § 4 (August 23, p. 407). Electro-positive bodies will be those which are most sensitive, and these will, according to the theory, attract other less electrified bodies. In the ordinary frictional electrical machine the glass will therefore be more strongly excited than the rubber. The explanation of the collecting action of points on the prime conductor is given by the consideration that at a point the molecules are more fully exposed to the electrical radiation from the glass plate, and being electrically excited by this radiation communicate their electrification to the prime conductor by conduction, as explained in § 13.

(2) Electrification by the action of heat takes place in the same manner, and it is clear that the molecules in crystals, being regularly disposed with their axes in definite directions, will be electrified. Thermo-electrical currents are also explained. For if one of the junctions of a circuit consisting of two dissimilar metals is heated, the more sensitive metal will receive more electrical energy than the other, and give rise to a positive current. The potential difference at the junction will depend on the internal constants of the molecules in the two metals, so that we cannot expect to be able to express it by any simple general law.

(3) Electrification by simple contact of two dissimilar metals is not so easily explained if the effects of heat, pressure, and friction are excluded. It is, however, possible that the close contact of differently vibrating molecules may disturb the internal and therefore the external energy, and thus give rise to electrification. The electrification of similar metals by contact could be explained in the same way.

(4) Electrification by chemical action is completely explained by the author's theory, the production of electrical vibrations by this means being exactly analogous to the similar production of heat- and light-vibrations. Such chemical action must, in the author's opinion, play an important part in the galvanic cell, though contact electrification may also have a share in the action. The contact between copper and sulphuric acid, for example, is a very intimate one. At ordinary temperatures the molecules of both substances will be in motion. When two different molecules collide, their internal equilibrium will be destroyed, and they will therefore, according to § 8 (September 6, p. 460) form a chemical compound, provided the critical vibrations of the compound are, at the given temperature, less easily excited than those of the separate elements, which we must assume to be the case, from the strong chemical affinity which is experimentally known to exist between copper and sulphuric acid. During this process electrification will take place if the maximum internal electrical energy is less for the compound than for the constituents, exactly as hydrogen in combining with oxygen to form water produces light, and chlorine in combining with hydrogen to form hydric chloride produces heat. The electricity set free will be carried away by the copper, the latter being a good conductor. The accumulation of electricity in the copper is prevented, however, by its being used up again in forming a chemical compound with the zinc.

G. W. DE TUNZELMANN.

(*To be continued.*)

## *COMPRESSIBILITY OF WATER, SALT WATER, MERCURY, AND GLASS.*[1]

THE pressures employed in the experiments ranged from 150 to 450 atmospheres, so that results given below for higher or lower pressures [and inclosed in square brackets] are extrapolated.

[1] Extracted, with the sanction of Dr. Murray, from a Report by Prof. Tait, now in type for a forthcoming volume of the *Challenger* publications.

A similar remark applies to temperature, the range experimentally treated for water and for sea-water being only 0° to 15° C. Also it has been stated that the recording indices are liable to be washed down the tube, to a small extent, during the relief of pressure, so that the results given are probably a little too *small*.

| | |
|---|---|
| Compressibility of mercury, per atmosphere ... ... | 0·0000036 |
| " " glass ... ... ... ... ... ... | 0·0000026 |

Average compressibility of fresh water per atmosphere—

| | | | |
|---|---|---|---|
| [At low pressures ... ... | $520 \cdot 10^{-7}$ – | $355 \cdot 10^{-9}t$ + | $3 \cdot 10^{-9}t^2$] |
| For 1 ton = 152·3 atm. | 504 | 360 | 4 |
| 2 " = 304·6 " | 490 | 365 | 5 |
| 3 " = 456·9 " | 478 | 370 | 6 |

The term independent of $t$ (the compressibility at 0° C.) is of the form—

$$10^{-7}(520 - 17p + p^2),$$

where the unit of $p$ is 152·3 atmospheres (1 ton-weight per square inch). This must not be extended in application much beyond $p = 3$, for there is no warrant, experimental or other, for the minimum which it would give at $p = 8·5$.

The point of minimum compressibility of fresh water is probably about 60° C. at atmospheric pressure, but is lowered by increase of pressure.

As an *approximation* through the whole range of the experiments we have the formula—

$$\frac{0·00186}{36 + p}\left(1 - \frac{3t}{400} + \frac{t^2}{10000}\right);$$

while the following formula exactly represents the average of all the experimental results at each temperature and pressure—

$$10^{-7}(520 - 17p + p^2) - 10^{-9}(355 + 5p)t + 10^{-9}(3 + p)t^2.$$

Average compressibility of sea-water (about 0·92 of that of fresh water)—

| | | | |
|---|---|---|---|
| [At low pressures ... | $481 \cdot 10^{-7}$ – | $340 \cdot 10^{-9}t$ + | $3 \cdot 10^{-9}t^2$] |
| For 1 ton ... | 462 | 320 | 4 |
| 2 " ... | 447·5 | 305 | 5 |
| 3 " ... | 437·5 | 295 | 5 |

Term independent of $t$—

$$10^{-7}(481 - 21·25p + 2·25p^2).$$

*Approximate* formula—

$$\frac{0·00179}{38 + p}\left(1 - \frac{t}{150} + \frac{t^2}{10000}\right).$$

Minimum compressibility point, probably about 56° C. at atmospheric pressure, is lowered by increase of pressure.

Average compressibility of solutions of NaCl for the first $p$ tons of additional pressure at 0° C. :—

$$\frac{0·00186}{36 + p + s},$$

where $s$ of NaCl is dissolved in 100 of water.

Note the remarkable resemblance between this and the formula for the average compressibility of fresh water at 0° C., and $p + s$ tons of additional pressure.

[Various parts of the investigation seem to favour Laplace's view that there is a large molecular pressure in liquids. In the text it has been suggested, in accordance with a formula of the kinetic theory of gases, that in water this may amount to about 36 tons-weight on the square inch. In a similar way it would appear that the molecular pressure in salt solutions is greater than that in water by an amount directly proportional to the quantity of salt added.]

Six miles of sea, at 10° C. throughout, are reduced in depth 620 feet by compression. At 0° C. the amount would be about 663 feet, or a furlong. (This quantity varies nearly as the square of the depth). Hence the pressure at a depth of 6 miles is nearly 1000 atmospheres.

The maximum-density point of water is lowered about 3° C. by 150 atmospheres of additional pressure.

From the heat developed by compression of water I obtained a lowering of 3° C. per ton-weight per square inch.

From the ratio of the volumes of water (under atmospheric pressure) at 0° C. and 4° C., given by Despretz, combined with my results as to the compressibility, I found 3°·17 C. ; and by direct experiment (a modified form of that of Hope) 2°·7 C. The circumstances of this experiment make it certain that the last result is too small.

Thus, at ordinary temperatures, the expansibility of water is increased by the application of pressure.

In consequence, the heat developed by sudden compression of water at temperatures above 4° C. increases in a higher ratio than the pressure applied; and water under 4° C. may be heated by the sudden application of sufficient pressure.

The maximum density coincides with the freezing-point at – 2°·4 C., under a pressure of 2·14 tons.

## SCIENTIFIC SERIALS.

In the *Journal of Botany* for August and September, a considerable portion is occupied by the continuation of papers, to which reference has already been made—Messrs. Britten and Boulger's biographical index of British and Irish botanists, and Mr. G. Murray's catalogue of the marine Algæ of the West Indian region.—Mr. W. H. Beeby records an addition to the British Phanerogamic flora in *Callitriche polymorpha*.—Mr. A. Fryer has some critical remarks on *Potamogeton fluitans*.—A number of new ferns from Western China, and from Manipur, in India, are described by Mr. J. G. Baker and Colonel Beddome.

The numbers of the *Botanical Gazette* for June–August contain quite an unusual number of articles of general interest. Bryologists will find a description of eight new species of moss from North America, each illustrated by a plate ; in fact, the plates in these three numbers are very numerous and excellent.—Mr. Chas. Robertson discusses the origin of zygomorphic flowers from the point of view of evolution.—Of flowering plants, we have descriptions of new species from Western America (chiefly Umbelliferæ) and from Guatemala, by Messrs. Coulter and Rose and Mr. J. D. Smith.—Mr. F. C. Newcombe describes the mode of dissemination of the spores of Equisetum in the splitting of the sporange and the carriage of the spores by means of the elaters.—Mr. A. F. Förste describes (with a plate) the adaptation to cross-fertilization in various species.

*American Journal of Mathematics*, 1888 (Baltimore, Johns Hopkins University).—The object of M. R. Liouville's paper, "Sur les lignes géodésiques des surfaces à courbure constante," with which vol. x. No. 4 opens, is stated by him to be "d'indiquer la signification géométrique des équations différentielles du second ordre ayant leur intégrale générale linéaire par rapport aux constantes arbitraires, et de former leurs invariants pour toutes les substitutions qui ne changent point, soit l'inconnue, soit la variable indépendante" (pp. 283–292).—The following memoir, on the primitive groups of transformations in space of four dimensions, by James M. Page, is likely to be very serviceable, as it is the first continuous account in English of the researches of Sophus Lie on the theory of groups of transformations. Lie himself has developed the theory in a series of papers which date from 1873, and has not published any connected work on the subject (pp. 293–346).—W. C. L. Gorton writes on line congruences. He treats the subject by quaternions, and obtains all Kummer's results (*Crelle*, vol. lvii.), and is enabled by his method to carry out certain steps which are only indicated by this writer (pp. 346–367).—The volume closes with a notelet by Prof. Franklin, entitled "Some Theorems concerning the Centre of Gravity." This contains "almost instantaneous" proofs of Lagrange's two theorems on the centre of gravity.

With vol. xi. No. 1, we have what strikes us as being an admirable likeness of the great French mathematician, Charles Hermite. We have previously expressed our pleasure at this new departure of the editors of this journal, and hope their catering for mathematicians will meet with material approval.—The first communication is a memoir on a new theory of symmetric functions, by Captain P. A. MacMahon, R.A. This prolific young mathematician is doing excellent work, and the pages of the journal are just suited to present his results in the most effective form. The paper is intimately connected with a recent one, by the same writer, communicated to the London Mathematical Society, in which he gives a sketch of an extension of the algebra of the theory of symmetrical functions, and establishes the basis of a wide development. "The main object of the memoir is to show clearly

the proper place of the 'symmetric function tables' as studied by Hirsch, Cayley, Durfee, and others, in the algebra of such functions; to point out that the fact of their existence depends upon a wide theorem of algebraic reciprocity which leads to an equally wide theorem of algebraic expressibility, and that they are a particular case, and not the most important case from the point of view of application, of a system of such tables" (pp. 1–36).—Prof. W. W. Johnson contributes a paper on the integrals in series of binomial differential equations (pp. 37–54). "Binomial equation" is here used in Boole's sense.—Some interesting geometrical results are given in the next paper, by M. d'Ocagne, "Sur certaines courbes qu'on peut adjoindre aux courbes planes pour l'étude de leurs propriétés infinitésimales" (pp. 55–70).—Prof. Cayley closes the number with an instalment on the surfaces with plane or spherical curves of curvature (pp. 71–98). The paper is a reproduction in a compact form, with additional developments, of papers by Bonnet (*Journal de l'École Polyt.*, t. xx., 1853, pp. 117–306), and Serret (Liouville, t. xviii., 1853, pp. 113–162).

*Engler's Jahrbücher*, vol. viii. Part 5, contains:—Contributions to the knowledge of the Cupuliferæ, by K. Prantl. The author concludes that the segments of the cupule are not themselves leaves, but outgrowths of the axis covered with leaves, and that, with the exception of this peculiarity, the male and female catkins are similarly constructed. His views will be stated in Engler's "Die Naturliche Pflanzenfamilien," for which this paper was a preparatory study.—A revision of Bentham and Hooker's "Genera Plantarum," and "Floræ Columbiæ specimia selecta," by H. Karsten.—The rest of the number is taken up with abstracts of botanical papers, and the list of the more important works on classification and geographical botany published in the year 1886.

Vol. ix. contains the following articles:—On the roots of the Araceæ, by Max Lierau. An investigation of the roots of about 130 species from 46 genera of this natural order, leads the author to the result that those histological characters by which the stem and leaf of the several sub-orders of Engler are distinguished recur also in the roots, and thus these organs, though performing the most various physiological functions, have constant characters of systematic value.—In his contributions to the knowledge of the Capparidaceæ, Dr. Ferd. Pax discusses the questions of (1) the part taken by the axis in the construction of the flower; (2) the relation of the Capparidoideæ to the Cleomoideæ, in respect of the andrœcium. He concludes that the disk, androphore, and gynophore, are of axial nature, and not the result of coalescence of sporophylls; further, that the construction of the andrœcium is uniform throughout the order, being based upon the presence of two dimerous whorls, increased often very greatly by duplication.—Observations on the organization and biological conditions of northern trees, by F. W. C. Areschoug.—Specilegium canariense, by H. Christ.—Dr. Marloth gives an interesting account of the morphology, anatomy, and biology of the Naras (*Acanthosicyos horrida*, Welw.) of the south-west coast of Africa, and of observations of the peculiar property of the fruit in promoting the coagulation of milk.—On the flora of the German East-Asiatic Protectorate, by K. Schumann.—Contributions to the morphology and classification of the Ranunculaceæ, by K. Prantl. The author distinguishes "honey-leaves" (*Honigblätter*) from the perianth, defining them as "floral leaves, the chief function of which is the secretion of honey, and which have been produced from stamens independently of the differentiation of the perianth into calyx and corolla": thus he would describe the corolla of Ranunculus as consisting of such "honey-leaves," while the calyx would be regarded as a simple perianth The greater part of the paper is occupied by the classification of the species within the genera.—New contributions to the flora of Greenland, by Eug. Warming.—Contributions to the knowledge of the walnut (*Juglans regia*, L.) by Dr. M. Kronfeld, with two plates.—A posthumous paper, by Dr. Hillebrand, descriptive of the vegetation of the Sandwich Islands.—Orchidaceæ herbarii Dom.-J Arechavatetæ det. et descr., by F. Kränzlin.—Dr. A. Breitfeld, in a paper on the anatomical structure of the leaves of the Rhododendroideæ, attempts to rank anatomical details with the characters of flower and fruit in the classification of the group, and finds the most useful characters in the epidermis.—On continuous and saltatory variation, by Franz Krašan.—Biographical notices on some of the collectors and authors named in the "Plantæ Ryddeanæ," by F. von Herder.—Marine Algæ of Puerto-Rico, by Dr. F. Hauck.—In addition to the above original treatises, the volume for the year contains a list of the papers of 1887 on the classification, description, and geological distribution of plants, as well as abstracts of the most important of these.

## SOCIETIES AND ACADEMIES.

### SYDNEY.

**Linnean Society of New South Wales**, July 25.—Dr. J. C. Cox, Vice-President, in the chair.—The following papers were read:—The insects of King's Sound and its vicinity, part 2, by William Macleay. This paper contains a list of all the Lamellicorn insects in the collection made by Mr. Froggatt in the West Kimberley district. Of the seventy-six species recorded, fifty-nine are described as new, but are all referable to known genera. The genera most numerous in species are *Onthophagus* and *Heteronyx*. The sub-family *Cetoniides* is represented by four species only.—Catalogue of the known Coleoptera of New Guinea, &c., part 2, by George Masters, Curator of the Macleay Museum. Part 2 of this catalogue, comprising the Tetramerous and Trimerous divisions, amounting to about 1100 species, completes the list of Coleoptera hitherto described from the region under consideration. The total number of species recorded is 2079.—Malaysian land and fresh-water Mollusca, by Rev. J. E. Tenison-Woods. After some introductory remarks on the extent and physical geography of the region under consideration, and on the characteristic features of its land and fresh-water Mollusca, the author gives a list of about 400 species indigenous to the Malay Peninsula in the States south of Keddah, and the Indian Archipelago, not including the Philippines and New Guinea. A bibliographical list is appended.—Mr. Ogilby exhibited a specimen of a deep-sea fish (*Chlorophthalmus nigripennis*), originally described by Dr. Günther in the *Ann. of Nat. Hist.*, 1878, and figured in vol. xxii. of the "*Challenger* Reports." The original specimens were taken by the *Challenger* naturalists off Twofold Bay, in 120 fathoms; the specimen exhibited was captured quite recently off Port Jackson in 70 fathoms, the only other occasion on which the species has been met with since its discovery.—Mr. Ogilby also exhibited a photograph of *Acanthias Blainvillii*, not hitherto recorded from New South Wales, and one of a variety of *Acanthoclinus littoreus*, originally described by Forster in "Cook's Voyage," the former having been taken in deep water off Port Jackson, the latter under stones between tide-marks at Lord Howe Island.—Mr. Brazier exhibited a spherical stone, about ½ inch in diameter, found in the crop of a Goura pigeon (*G. Albertisi*, Salvad.), from Hall Sound, New Guinea. Also a tube of fresh-water shells (*Segmentina australiensis*, E. A. Smith), from Waterloo Swamps.—Mr. MacDonald showed under the microscope an interesting exhibit of Rotifers (*Megalotrocha* sp.), living in clusters on pond weed.—Mr. Burnell exhibited two living slow-worms (*Typhlops nigrescens*), from Wentworthville, near Parramatta.—Mr. Deane exhibited a remarkable excrescence on a root of *Monotoca elliptica*, found by Mr. J. F. Fitzhardinge in the neighbourhood of Sydney; a specimen of an apodal lizard (*Delma impar*) found by Mr. C. F. Price, of Arable, near Cooma, where the species is said to be abundant in basaltic country; and examples of concretionary nodules occurring abundantly in a slaty rock in a cutting near Bredbo on the Goulburn to Cooma Railway.

### PARIS.

**Academy of Sciences**, October 1.—M. Des Cloizeaux in the chair.—Relative values of the two constituents of the force displayed in the stroke of a bird's wing, deduced from the direction and insertion of the fibres of the great pectoral muscle, by M. Marey. Of the forces in question, one, as shown in previous communications, equals the weight of the bird and enables it to resist gravitation, the other is horizontal and enables it to resist the air. From a study of the disposition of the muscular fibres of the breast, the author now infers that the latter force, contrary to the general opinion, is much greater, and may even be double that of the former.—Positions of Barnard's comet (September 2, 1888) measured at the Observatory of Besançon with the 0·22 m. equatorial, by M. Gruey. The observations cover the period from September 5–15.—Observations of Sawer-

thal's comet (1888, I.) made with the 0·38 m. equatorial at the Observatory of Bordeaux, by MM. G. Rayet and Courty. The observations range from April 4 to July 12.—Potential energy of the gravitation of a planet, by M. O. Callandreau. The object of this note is to show that the potential energy of a planet's gravitation—in other words, the power of attraction displayed in drawing the molecules from boundless space to their present position—may be approximately calculated if its dimensions, mass, and angular velocity of rotation be known, irrespective of the law of internal densities.—On actino-electric phenomena, by M. E. Bichat. The passage of electricity of high or feeble tension is known to be greatly facilitated when the electrified body is illumined by very refrangible radiations. In a previous communication it was shown that in Stoletow's experiment the substitution of a sheet of water for the metallic plate produces no deviation of the galvanometer, which seems to prove that the electricity is not transmitted by conduction. This inference is confirmed by the experiments here described. —On some new electric phenomena produced by radiations, by M. Auguste Righi. In continuation of previous researches, the author here reports a series of further results connected with the same order of phenomena.—On the employment of the sulphite of soda in photography, by M. Paul Poiré. The process here described has the advantage of avoiding the cloudiness produced by the prolonged action of the carbonate. Plates left forty-five minutes in the bath acquire a continual increase of intensity without presenting the least appearance of cloudiness. —On the land locomotion of reptiles and four-footed Batrachians compared with that of Mammalian quadrupeds, by M. G. Carlet. The locomotion of frogs, toads, lizards, and the like is described as a peculiar action, somewhat analogous to the trot of quadrupeds, and exactly like that of two men walking one behind the other with *contrary* step. It is a sort of slow trot, without any suspension of the body in the air.—M. Carlet communicates a supplementary paper in illustration of the same subject, on the locomotion of an insect rendered tetrapod by deprivation of the two middle legs. The experiment explains the persistence in all these organisms of the six legs, which appear to be not merely useful, but even necessary to secure stability and rapid locomotion.—A series of papers are contributed by MM. Philippe Thomas, P. Fliche, and Bleicher, on the petrified vegetation of Tunis. These fossils are shown to belong to the same Pliocene formation, and to be otherwise closely analogous to the well-known petrified forests in the neighbourhood of Cairo. Specimens of a like character have been picked up in Algeria and other parts of Mauritania, rendering it highly probable that the whole of North Africa, from the Mediterranean to the verge of the Sahara, was covered with a somewhat uniform vegetation in Pliocene times.

STOCKHOLM.

**Royal Academy of Sciences**, September 12.—Demonstration of a proposition, which touches upon the question of the stability of the planetary system, by Prof. Gyldén.—The same exhibited a calculating machine made by Herr Sörensen.—On a paper by Baron von Camerlander in Vienna, on the fall of meteoric dust in some parts of Austria in February this year, by Baron Nordenskiöld.—The same exhibited a new mineral from Pojsberg, which he had named Brandtit.—On crystals of native lead from Pojsberg, by Herr A. Hamberg.—On two new chlorides of indium, and on the density of the vapour of the chlorides of indium, gallium, iron, and chromium, by Profs. Nilsson and Pettersson.—On the theory of the numbers and functions of Bernoulli, based on a system of functional equations, by Dr. Berger.—On change of the sea-level at Altenfiord, by Commodore Littiehöök.—On some definite integrals, by Dr. C. F. Lindman.—Contributions to the theory of a singular solution of a partial differential equation with two independent variables, by Dr. J. Möller.—Observations on the condensation of the vapour of water in a humid, electrical atmosphere, by Herr G. A. Andrée.—On a species of Annelida living with hermit crabs, by Dr. Wirén.—On some derivates of $\alpha$-$\beta$-dichlor-naphthaline, by Herr P. Hellström.—On the former occurrence of *Felis catus* in Scania, by Prof. Qvennerstedt.—On Dahllit, a new mineral from Bamle, in Norway, by Prof. W. C. Brögger and Herr H. Bäckström.—On the freezing-point of dilute aqueous solutions, by Dr. S. Arrhenius.—Galvanometric measurements on the influence that is exercised by an electric spark on another spark, by Dr. C. A. Mebius.

## BOOKS, PAMPHLETS, and SERIALS RECEIVED.

Untersuchungen zur Morphologie und Systematik der Vögel; I. Specieller Theil, II. Allgemeiner Theil: Max Fürbringer (T. Van Holkema, Amsterdam).—Fossils of the British Islands; Vol. i. Palæozoic: R. Etheridge (Clarendon Press).—A Class-book of Elementary Chemistry: W. W. Fisher (Clarendon Press).—General Report on the Operations of the Survey of India Department during 1886-87 (Calcutta).—Fourfold Root and Will in Nature: A. Schopenhauer (Bell).—University College, Liverpool, Calendar for the Session 1888-89 (Holden, Liverpool).—Papers and Proceedings of the Royal Society of Tasmania for 1887 (Tasmania).—Laboratory Manual of General Chemistry: R. P. Williams (Ginn, Boston).—An Introduction to Practical Inorganic Chemistry: W. Jago (Longmans).—Les Formes du Terrain, Texte et Planches: G. de la Noë and E. de Margerie (Paris).—The International Annual of Anthony's Photographic Bulletin (Greenwood).—A Catalogue of the Moths of India, Part 3: E. C. Cotes and C. Swinhoe (Calcutta).—Sixth Annual Report of the Fishery Board for Scotland, for the year 1887; Three Parts (Edinburgh).—Instruction in Photography; eighth edition: Captain W. de W. Abney (Piper and Carter).—The Metallurgy of Gold: M. Eissler (Lockwood).—Key to Lock's Arithmetic for Schools: Rev. R. G. Watson (Macmillan).—Report on the Eruption of Tarawera and Rotomahana, N.Z.: A. P. W. Thomas (Wellington, N.Z.).—Die Schwankungen der Hocharmenischen Seen Seit 1800: Dr. R. Sieger (Wien).—Bulletin du Comité International Permanent pour l'Exécution Photographique de la Carte du Ciel, 2e Fascicule (Gauthier-Villars, Paris).—Die Fossile Pflanzen-Gattung Tylodendron: H. Potonié (Berlin).—Ueber den Einfluss niederer Sauerstoffpressungen auf die Bewegungen des Protoplasmas: J. Clark (Berlin).—Der Feuerstoff: L. Mann (Berlin).—The Minerals of New York County, U.S.A. (New York).—Journal of the Chemical Society, October (Gurney and Jackson).—Bulletin de l'Académie Impériale des Sciences de St. Pétersbourg, tome xxxii. Nos. 2 and 4.

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